After calculating the average market equity ris it by the Beta coefficient to account for the risk of the Utility Proxy Group. As discussed below, the Beta coefficient is a meaningful measure of prospective relative risk to the market as a whole, and is a logical way to allocate a company's, or proxy group's, share of the market's total equity risk premium relative to corporate bond yields. As shown on page 1 of Schedule DWD-5, the average of the mean and median Beta coefficient for the Utility Proxy Group is 0.95. Multiplying the 0.95 average Beta coefficient by the market equity risk premium of 9.92% results in a Beta-adjusted equity risk premium for the Utility Proxy Group of 9.42%.

Q. HOW DID YOU DERIVE THE EQUITY RISK PREMIUM BASED ON THE S&P UTILITY INDEX AND MOODY'S A-RATED PUBLIC UTILITY BONDS?

A. I estimated three equity risk premiums based on S&P Utility Index holding period returns, and two equity risk premiums based on the expected returns of the S&P Utilities Index, using *Value Line* and Bloomberg data, respectively. Turning first to the S&P Utility Index holding period returns, I derived a long-term monthly arithmetic mean equity risk premium between the S&P Utility Index total returns of 10.74% and monthly Moody's A-rated public utility bond yields of 6.53% from 1928 to 2019 to arrive at an equity risk premium of 4.21%.[45] I then used the same historical data to derive an equity risk premium of 6.76% based on a regression of the monthly equity risk premiums. The final S&P Utility Index holding period equity risk premium involved applying the PRPM using the historical monthly equity risk premiums from January 1928 to July 2020 to arrive premium of 5.57% for the S&P Utility Index.

I then derived expected total returns on the S&P Utilities Index of 10.57% and 9.04% using data from *Value Line* and Bloomberg, respectively, and subtracted the prospective Moody's A2-rated public utility bond yield of 3.64%[46], which resulted in equity risk premiums of 6.93% and 5.40%, respectively. As with the market equity risk premiums, I averaged each risk premium based on each source (*i.e.*, historical, *Value Line*, and Bloomberg) to arrive at my utility-specific equity risk premium of 5.77%.

Table 7: Summary of the Calculation of the Equity Risk Premium using S&P Utility Index Holding Returns[47]

Historical Spread Between Total Returns of the S&P Utilities Index and A2-Rated Utility Bond Yields (1928 – 2019)	4.21%
Regression Analysis on Historical Data	6.76%
PRPM Analysis on Historical Data	5.57%
Prospective Equity Risk Premium using Measures of Capital Appreciation and Income Returns from *Value Line* for the S&P Utilities Index less Projected A2 Utility Bond Yields	6.93%
Prospective Equity Risk Premium using Measures of Capital Appreciation and Income Returns from Bloomberg Professional Services for the S&P Utilities Index less Projected A2 Utility Bond Yields	5.40%
Average	5.77%

Q. HOW DO YOU DERIVE AN EQUITY RISK PREMIUM OF 5.88% BASED ON AUTHORIZED ROES FOR ELECTRIC UTILITIES?

45 As shown on line 1, page 12 of Schedule DWD-4.
46 Derived on line 3, page 3 of Schedule DWD-4.
47 As shown on page 12 of Schedule DWD-4.

A. The equity risk premium of 5.88% shown on line 3, the result of a regression analysis based on regulatory awarded ROEs related to the yields on Moody's A2-rated public utility bonds. That analysis is shown on page 13 of Schedule DWD-4. Page 13 of Schedule DWD-4 contains the graphical results of a regression analysis of 1,167 rate cases for electric utilities which were fully litigated during the period from January 1, 1980 through July 31, 2019. It shows the implicit equity risk premium relative to the yields on A2-rated public utility bonds immediately prior to the issuance of each regulatory decision. It is readily discernible that there is an inverse relationship between the yield on A2-rated public utility bonds and equity risk premiums. In other words, as interest rates decline, the equity risk premium rises and vice versa, a result consistent with financial literature on the subject.[48] I used the regression results to estimate the equity risk premium applicable to the projected yield on Moody's A2-rated public utility bonds. Given the expected A2-rated utility bond yield of 3.64%, it can be calculated that the indicated equity risk premium applicable to that bond yield is 5.88%, which is shown on line 3, page 7 of Schedule DWD-4.

Q. WHAT IS YOUR CONCLUSION OF AN EQUITY RISK PREMIUM FOR USE IN YOUR TOTAL MARKET APPROACH RPM ANALYSIS?

A. The equity risk premium I apply to the Utility Proxy Group is 7.02%, which is the average of the Beta-adjusted equity risk premium for the Utility Proxy Group, the

48 *See, e.g.*, Robert S. Harris and Felicia C. Marston, *The Market Risk Premium. Expectational Estimates Using Analysts' Forecasts*, Journal of Applied Finance, Vol. 11, No. 1, 2001, at 11-12; Eugene F. Brigham, Dilip K. Shome, and Steve R. Vinson, *The Risk Premium Approach to Measuring a Utility's*

S&P Utilities Index, and the authorized return utility ε 5.77%, and 5.88%, respectively.[49]

Q. WHAT IS THE INDICATED RPM COMMON EQUITY COST RATE BASED ON THE TOTAL MARKET APPROACH?

A. As shown on line 7, page 3 of Schedule DWD-4 and shown on Table 8, below, I calculated a common equity cost rate of 10.80% for the Utility Proxy Group based on the total market approach RPM.

Table 8: Summary of the Total Market Return Risk Premium Model[50]

Prospective Moody's A3-Rated Utility Bond Applicable to the Utility Proxy Group	3.78%
Prospective Equity Risk Premium	7.02%
Indicated Cost of Common Equity	10.80%

Q. WHAT ARE THE RESULTS OF YOUR APPLICATION OF THE PRPM AND THE TOTAL MARKET APPROACH RPM?

A. As shown on page 1 of Schedule DWD-4, the indicated RPM-derived common equity cost rate is 10.54%, which gives equal weight to the PRPM (10.27%) and the adjusted-market approach results (10.80%).

C. The Capital Asset Pricing Model

Q. PLEASE EXPLAIN THE THEORETICAL BASIS OF THE CAPM.

A. CAPM theory defines risk as the co-variability of a security's returns with the market's returns as measured by the Beta coefficient (β). A Beta coefficient less than

Cost of Equity, Financial Management, Spring 1985, at 33-45.

49 As shown on page 7 of Schedule DWD-4.

50 As shown on page 3 of Schedule DWD-4.

1.0 indicates lower variability than the market as a w
greater than 1.0 indicates greater variability than the market.

The CAPM assumes that all non-market or unsystematic risk can be eliminated through diversification. The risk that cannot be eliminated through diversification is called market, or systematic, risk. In addition, the CAPM presumes that investors only require compensation for systematic risk, which is the result of macroeconomic and other events that affect the returns on all assets. The model is applied by adding a risk-free rate of return to a market risk premium, which is adjusted proportionately to reflect the systematic risk of the individual security relative to the total market as measured by the Beta coefficient. The traditional CAPM model is expressed as:

$$R_s = R_f + \beta (R_m - R_f)$$

Where: R_s = Return rate on the common stock;

R_f = Risk-free rate of return;

R_m = Return rate on the market as a whole; and

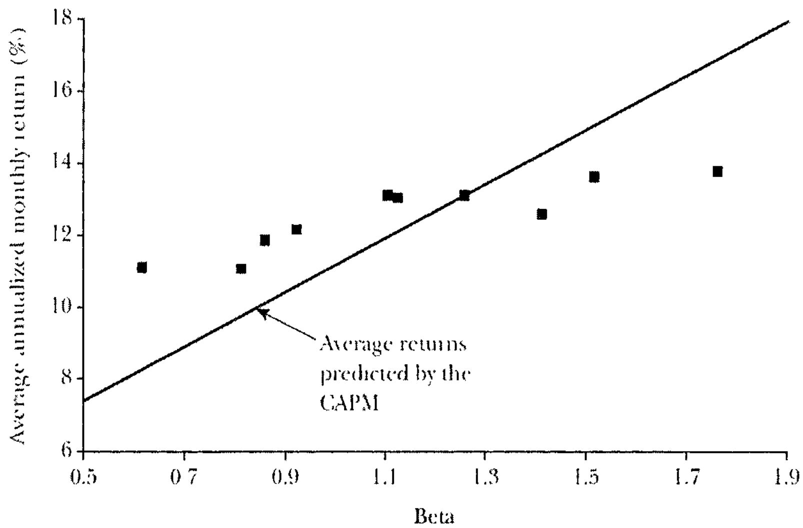
β = Adjusted Beta coefficient (volatility of the security relative to the market as a whole)

Numerous tests of the CAPM have measured the extent to which security returns and Beta coefficients are related as predicted by the CAPM, confirming its validity. The empirical CAPM ("ECAPM") reflects the reality that while the results of these tests support the notion that the Beta coefficient is related to security returns, the empirical Security Market Line ("SML") describe as steeply sloped as the predicted SML.[51]

The ECAPM reflects this empirical reality. Fama and French clearly state regarding Figure 2, below, that "[t]he returns on the low beta portfolios are too high, and the returns on the high beta portfolios are too low."[52]

Figure 2 http://pubs.aeaweb.org/doi/pdfplus/10.1257/0895330042162430

Average Annualized Monthly Return versus Beta for Value Weight Portfolios Formed on Prior Beta, 1928–2003



In addition, Morin observes that while the results of these tests support the notion that Beta is related to security returns, the empirical SML described by the CAPM formula is not as steeply sloped as the predicted SML. Morin states:

> With few exceptions, the empirical studies agree that … low-beta securities earn returns somewhat higher than the CAPM would predict, and high-beta securities earn less than predicted.[53]

---

51 Roger A. Morin, New Regulatory Finance, , at page 175 ("Morin").

52 Eugene F. Fama and Kenneth R. French, *The Capital Asset Pricing Model: Theory and Evidence*, Journal of Economic Perspectives, Vol. 18, No. 3, Summer 2004 at 33 ("Fama & French").

53 Morin, at 175.

* * *

> Therefore, the empirical evidence suggests that the expected return on a security is related to its risk by the following approximation:
>
> $$K = R_F + x\,(R_M - R_F) + (1-x)\ \beta(R_M - R_F)$$
>
> where x is a fraction to be determined empirically. The value of x that best explains the observed relationship [is] Return = 0.0829 + 0.0520 β is between 0.25 and 0.30. If x = 0.25, the equation becomes:
>
> $$K = R_F + 0.25(R_M - R_F) + 0.75\ \beta(R_M - R_F)$$[54]

Fama and French provide similar support for the ECAPM when they state:

> The early tests firmly reject the Sharpe-Lintner version of the CAPM. There is a positive relation between beta and average return, but it is too 'flat.'... The regressions consistently find that the intercept is greater than the average risk-free rate... and the coefficient on beta is less than the average excess market return... This is true in the early tests... as well as in more recent cross-section regressions tests, like Fama and French (1992).[55]

Finally, Fama and French further note:

> Confirming earlier evidence, the relation between beta and average return for the ten portfolios is much flatter than the Sharpe-Linter CAPM predicts. The returns on low beta portfolios are too high, and the returns on the high beta portfolios are too low. For example, the predicted return on the portfolio with the lowest beta is 8.3 percent per year; the actual return as 11.1 percent. The predicted return on the portfolio with the t beta is 16.8 percent per year; the actual is 13.7 percent.[56]

Clearly, the justification from Morin, Fama, and French, along with their reviews of other academic research on the CAPM, validate the use of the ECAPM. In view of theory and practical research, I have applied both the traditional CAPM

54 Morin, at 190.
55 Fama & French, at 32.
56 *Ibid*, at 33.

and the ECAPM to the companies in the Utility P results.

Q. WHAT BETA COEFFICIENTS DID YOU USE IN YOUR CAPM ANALYSIS?

A. For the Beta coefficients in my CAPM analysis, I considered two sources: *Value Line* and Bloomberg Professional Services. While both of those services adjust their calculated (or "raw") Beta coefficients to reflect the tendency of the Beta coefficient to regress to the market mean of 1.00, *Value Line* calculates the Beta coefficient over a five-year period, while Bloomberg calculates it over a two-year period.

Q. PLEASE DESCRIBE YOUR SELECTION OF A RISK-FREE RATE OF RETURN.

A. As shown in Column 5, page 1 of Schedule DWD-5, the risk-free rate adopted for both applications of the CAPM is 2.09%. This risk-free rate is based on the average of the *Blue Chip* consensus forecast of the expected yields on 30-year U.S. Treasury bonds for the six quarters ending with the fourth calendar quarter of 2021, and long-term projections for the years 2022 to 2026 and 2027 to 2031.

Q. WHY IS THE YIELD ON LONG-TERM U.S. TREASURY BONDS APPROPRIATE FOR USE AS THE RISK-FREE RATE?

A. The yield on long-term U.S. Treasury bonds is almost risk-free and its term is consistent with the long-term cost of capital to public utilities measured by the yields on Moody's A-rated public utility bonds; the long-term investment horizon inherent in utilities' common stocks; and the long-term life of the jurisdictional rate base to which the allowed fair rate of return (*i.e.*, cost of capital) will be applied. In contrast, short-term U.S. Treasury yields are more volatile an Reserve monetary policy.

Q. PLEASE EXPLAIN THE ESTIMATION OF THE EXPECTED RISK PREMIUM FOR THE MARKET USED IN YOUR CAPM ANALYSES.

A. The basis of the market risk premium is explained in detail in note 1 on Schedule DWD-5. As discussed above, the market risk premium is derived from an average of three historical data-based market risk premiums, two *Value Line* data-based market risk premiums, and one Bloomberg data-based market risk premium.

The long-term income return on U.S. Government securities of 5.09% was deducted from the SBBI - 2020 monthly historical total market return of 12.10%, which results in an historical market equity risk premium of 7.01%.[57] I applied a linear OLS regression to the monthly annualized historical returns on the S&P 500 relative to historical yields on long-term U.S. Government securities from SBBI - 2020. That regression analysis yielded a market equity risk premium of 10.20%. The PRPM market equity risk premium is 10.67%, and is derived using the PRPM relative to the yields on long-term U.S. Treasury securities from January 1926 through July 2020.

The *Value Line*-derived forecasted total market equity risk premium is derived by deducting the forecasted risk-free rate of 2.09%, discussed above, from the *Value Line* projected total annual market return of 16.53%, resulting in a forecasted total market equity risk premium of 14.44%. The S&P 500 projected market equity risk premium using *Value Line* data projected risk-free rate of 2.09% from the projected total return of the S&P 500 of 13.66%. The resulting market equity risk premium is 11.57%.

The S&P 500 projected market equity risk premium using Bloomberg data is derived by subtracting the projected risk-free rate of 2.09% from the projected total return of the S&P 500 of 13.75%. The resulting market equity risk premium is 11.66%. These six measures, when averaged, result in an average total market equity risk premium of 10.92%.

Table 9: Summary of the Calculation of the Market Risk Premium for use in the CAPM[58]

Historical Spread Between Total Returns of Large Stocks and Long-Term Government Bond Yields (1926 – 2019)	7.01%
Regression Analysis on Historical Data	10.20%
PRPM Analysis on Historical Data	10.67%
Prospective Equity Risk Premium using Total Market Returns from *Value Line* Summary & Index less Projected 30-Year Treasury Bond Yields	14.44%
Prospective Equity Risk Premium using Measures of Capital Appreciation and Income Returns from *Value Line* for the S&P 500 less Projected 30-Year Treasury Bond Yields	11.57%
Prospective Equity Risk Premium using Measures of Capital Appreciation and Income Returns from Bloomberg Professional Services for the S&P 500 less Projected 30-Year Treasury Bond Yields	11.66%
Average	10.92%

Q. WHAT ARE THE RESULTS OF YOUR APPLICATION OF THE TRADITIONAL AND EMPIRICAL CAPM TO THE UTILITY PROXY GROUP?

57 SBBI - 2020, at Appendix A-1 (1) through A-1 (3) and Appendix A-7 (19) through A-7 (21).
58 As shown on page 2 of Schedule DWD-5.

A. As shown on page 1 of Schedule DWD-5, the mean analyses is 12.61%, the median is 12.30%, and the average of the two is 12.46%. Consistent with my reliance on the average of mean and median DCF results discussed above, the indicated common equity cost rate using the CAPM/ECAPM is 12.46%.

D. Common Equity Cost Rates for a Proxy Group of Domestic, Non-Price Regulated Companies Based on the DCF, RPM, and CAPM

Q. WHY DO YOU ALSO CONSIDER A PROXY GROUP OF DOMESTIC, NON-PRICE REGULATED COMPANIES?

A. In the *Hope* and *Bluefield* cases, the U.S. Supreme Court did not specify that comparable risk companies had to be utilities. Since the purpose of rate regulation is to be a substitute for marketplace competition, non-price regulated firms operating in the competitive marketplace make an excellent proxy if they are comparable in total risk to the Utility Proxy Group being used to estimate the cost of common equity. The selection of such domestic, non-price regulated competitive firms theoretically and empirically results in a proxy group which is comparable in total risk to the Utility Proxy Group, since all of these companies compete for capital in the exact same markets.

Q. HOW DID YOU SELECT NON-PRICE REGULATED COMPANIES THAT ARE COMPARABLE IN TOTAL RISK TO THE UTILITY PROXY GROUP?

A. In order to select a proxy group of domestic, non-price regulated companies similar in total risk to the Utility Proxy Group, I relied on the Beta coefficients and related statistics derived from *Value Line* regression analyse the most recent 260 weeks (*i.e.*, five years). These selection criteria resulted in a proxy group of 45 domestic, non-price regulated firms comparable in total risk to the Utility Proxy Group. Total risk is the sum of non-diversifiable market risk and diversifiable company-specific risks. The criteria used in selecting the domestic, non-price regulated firms was:

(i) They must be covered by *Value Line* (Standard Edition);

(ii) They must be domestic, non-price regulated companies, *i.e.*, not utilities;

(iii) Their Beta coefficients must lie within plus or minus two standard deviations of the average unadjusted Beta coefficients of the Utility Proxy Group; and

(iv) The residual standard errors of the *Value Line* regressions which gave rise to the unadjusted Beta coefficients must lie within plus or minus two standard deviations of the average residual standard error of the Utility Proxy Group.

Beta coefficients measure market, or systematic, risk, which is not diversifiable. The residual standard errors of the regressions measure each firm's company-specific, diversifiable risk. Companies that have similar Beta coefficients <u>and</u> similar residual standard errors resulting from the same regression analyses have similar total investment risk.

Q. HAVE YOU PREPARED A SCHEDULE WHICH SHOWS THE DATA FROM WHICH YOU SELECTED THE 45 DOMESTIC, NON-PRICE REGULATED COMPANIES THAT ARE COMPARABLE IN TOTAL RISK TO THE UTILITY PROXY GROUP?

A. Yes, the basis of my selection and both proxy groups' in Schedule DWD-6.

Q. DID YOU CALCULATE COMMON EQUITY COST RATES USING THE DCF MODEL, RPM, AND CAPM FOR THE NON-PRICE REGULATED PROXY GROUP?

A. Yes. Because the DCF model, RPM, and CAPM have been applied in an identical manner as described above, I will not repeat the details of the rationale and application of each model. One exception is in the application of the RPM, where I did not use public utility-specific equity risk premiums, nor did I apply the PRPM to the individual non-price regulated companies.

Page 2 of Schedule DWD-7 derives the constant growth DCF model common equity cost rate. As shown, the indicated common equity cost rate, using the constant growth DCF for the Non-Price Regulated Proxy Group comparable in total risk to the Utility Proxy Group, is 11.50%.

Pages 3 through 5 of Schedule DWD-7 contain the data and calculations that support the 12.86% RPM common equity cost rate. As shown on line 1, page 3 of Schedule DWD-7, the consensus prospective yield on Moody's Baa-rated corporate bonds for the six quarters ending in the fourth quarter of 2021, and for the years 2022 to 2026 and 2027 to 2031, is 4.18%.[59] Since the Non-Price Regulated Proxy Group has an average Moody's long-term issuer rating of A3/Baa1, a downward adjustment of 0.35% to the projected Baa2-rated corporate bond yield is necessary to reflect the difference in ratings which results in a projected A3/B of 3.83%.

When the Beta-adjusted risk premium of 9.03%[60] relative to the Non-Price Regulated Proxy Group is added to the prospective A3/Baa1-rated corporate bond yield of 3.83%, the indicated RPM common equity cost rate is 12.86%.

Page 6 of Schedule DWD-7 contains the inputs and calculations that support my indicated CAPM/ECAPM common equity cost rate of 12.09%.

Q. WHAT IS THE COST RATE OF COMMON EQUITY BASED ON THE NON-PRICE REGULATED PROXY GROUP COMPARABLE IN TOTAL RISK TO THE UTILITY PROXY GROUP?

A. As shown on page 1 of Schedule DWD-7, the results of the common equity models applied to the Non-Price Regulated Proxy Group – which group is comparable in total risk to the Utility Proxy Group – are as follows: 11.50% (DCF), 12.86% (RPM), and 12.09% (CAPM). The average of the mean and median of these models is 12.12%, which I used as the indicated common equity cost rates for the Non-Price Regulated Proxy Group.

---

59 *Blue Chip Financial Forecasts*, June 1, 2020, at page 14 and July 31, 2020, at page 2.
60 Derived on page 5 of Schedule DWD-7.

VIII. CONCLUSION OF COMMON EQUITY C ADJUSTMENTS

Q. WHAT IS THE INDICATED COMMON EQUITY COST RATE BEFORE ADJUSTMENTS?

A. By applying multiple cost of common equity models to the Utility Proxy Group and the Non-Price Regulated Proxy Group, the indicated range of common equity cost rates attributable to the Utility Proxy Group before any relative risk adjustments is between 9.85% and 10.96%. I used multiple cost of common equity models as primary tools in arriving at my recommended common equity cost rate, because no single model is so inherently precise that it can be relied on to the exclusion of other theoretically sound models. Using multiple models adds reliability to the estimated common equity cost rate, with the prudence of using multiple cost of common equity models supported in both the financial literature and regulatory precedent.

Based on these common equity cost rate results, I conclude that a range of common equity cost rates between 9.85% and 10.96% is reasonable and appropriate before any adjustments for relative risk differences between SWEPCO and the Utility Proxy Group are made. The bottom of the indicated range (*i.e.,* 9.85%) was calculated by averaging the average of all model results (10.96%) with the lowest model result (8.73%), and the top of the indicated range is the approximate average of all model results. I have chosen this indicated range of common equity cost rates applicable to the Utility Proxy Group in order to be conservative in view of current market volatility and uncertainty as discussed previously.

IX. ADJUSTMENTS TO THE COMMON E

A. Size Adjustment

Q. DOES SWEPCO'S SMALLER SIZE RELATIVE TO THE UTILITY PROXY GROUP COMPANIES INCREASE ITS BUSINESS RISK?

A. Yes. SWEPCO's smaller size relative to the Utility Proxy Group companies indicates greater relative business risk for the Company because, all else being equal, size has a material bearing on risk.

Size affects business risk because smaller companies generally are less able to cope with significant events that affect sales, revenues and earnings. For example, smaller companies face more risk exposure to business cycles and economic conditions, both nationally and locally. Additionally, the loss of revenues from a few larger customers would have a greater effect on a small company than on a bigger company with a larger, more diverse, customer base.

As further evidence that smaller firms are riskier, investors generally demand greater returns from smaller firms to compensate for less marketability and liquidity of their securities. Duff & Phelps' 2020 Valuation Handbook – U.S. Guide to Cost of Capital ("D&P – 2020") discusses the nature of the small-size phenomenon, providing an indication of the magnitude of the size premium based on several measures of size. In discussing "Size as a Predictor of Equity Returns," D&P – 2020 states:

> The size effect is based on the empirical observation that companies of smaller size are associated with greater risk and, therefore, have greater cost of capital [sic]. The "size" of a company is one of the most important risk elements to consider when developing cost of

> equity capital estimates for use in valuing a b size has been shown to be a *predictor* of equity returns. In other words, there is a significant (negative) relationship between size and historical equity returns - as size *decreases*, returns tend to *increase*, and vice versa. (footnote omitted) (emphasis in original)[61]

Furthermore, in "The Capital Asset Pricing Model: Theory and Evidence," Fama and French note size is indeed a risk factor which must be reflected when estimating the cost of common equity. On page 14, they note:

> . . . the higher average returns on small stocks and high book-to-market stocks reflect unidentified state variables that produce undiversifiable risks (covariances) in returns not captured in the market return and are priced separately from market betas.[62]

Based on this evidence, Fama and French proposed their three-factor model which includes a size variable in recognition of the effect size has on the cost of common equity.

Also, it is a basic financial principle that the use of funds invested, and not the source of funds, is what gives rise to the risk of any investment.[63] Eugene Brigham, a well-known authority, states:

> A number of researchers have observed that portfolios of small-firms (sic) have earned consistently higher average returns than those of large-firm stocks; this is called the "small-firm effect." On the surface, it would seem to be advantageous to the small firms to provide average returns in a stock market that are higher than those of larger firms. In reality, it is bad news for the small firm; **what the small-firm effect means is that the capital market demands higher returns on stocks of small firms than on otherwise similar stocks of the large firms**. (emphasis added)[64]

---

61 Duff & Phelps Valuation Handbook – U.S. Guide to Cost of Capital, Wiley 2020, at 4-1.

62 Fama & French, at 25-43.

63 Brealey, Richard A. and Myers, Stewart C., Principles of Corporate Finance (McGraw-Hill Book Company, 1996), at 204-205, 229.

64 Brigham, Eugene F., Fundamentals of Financial Management, Fifth Edition (The Dryden Press, 1989), at 623.

Consistent with the financial principle of ris increased relative risk due to small size must be considered in the allowed rate of return on common equity. Therefore, the Commission's authorization of a cost rate of common equity in this proceeding must appropriately reflect the unique risks of SWEPCO, including its small relative size, which is justified and supported above by evidence in the financial literature.

Q. IS THERE A WAY TO QUANTIFY A RELATIVE RISK ADJUSTMENT DUE TO SWEPCO'S SMALL SIZE WHEN COMPARED TO THE UTILITY PROXY GROUP?

A. Yes. SWEPCO has greater relative risk than the average utility in the Utility Proxy Group because of its smaller size, as measured by an estimated market capitalization of common equity for SWEPCO.

Table 10: Size as Measured by Market Capitalization for SWEPCO's Electric Operations and the Utility Proxy Group

	Market Capitalization* ($ Millions)	Times Greater than The Company
SWEPCO	$1,709	
Utility Proxy Group	$14,860	8.7x
*From page 1 of Schedule DWD-8.		

SWEPCO's estimated market capitalization was $1,709 million as of July 31, 2020, compared with the market capitalization of the average company in the Utility Proxy Group of $14,860 million as of July 31, 2020. The average company in the Utility Proxy Group has a market capitalization 8.7 times the size of SWEPCO's estimated market capitalization.

As a result, it is necessary to upwardly adjust the indicated range of common equity cost rates attributable to the Utility Proxy Group to reflect SWEPCO's greater risk due to their smaller relative size. The determination is based on the size premiums for portfolios of New York Stock Exchange, American Stock Exchange, and NASDAQ listed companies ranked by deciles for the 1926 to 2019 period. The average size premium for the Utility Proxy Group with a market capitalization of $14,860 million falls in the second decile, while the Company's estimated market capitalization of $1,709 million places it in the sixth decile. The size premium spread between the second decile and the sixth decile is 0.84%. Even though an 0.84% upward size adjustment is indicated, I applied a size premium of 0.20% to the Company's indicated common equity cost rate.

Q. SINCE SWEPCO IS PART OF A LARGER COMPANY, WHY IS THE SIZE OF THE TOTAL COMPANY NOT MORE APPROPRIATE TO USE WHEN DETERMINING THE SIZE ADJUSTMENT?

A. The return derived in this proceeding will not apply to AEP's operations as a whole, but only SWEPCO's. AEP is the sum of its constituent parts, including those constituent parts' ROEs. Potential investors in the Parent are aware that it is a combination of operations in each state, and that each state's operations experience the operating risks specific to their jurisdiction. The market's expectation of AEP's return is commensurate with the realities of the Company's composite operations in each of the states in which it operates.

B. Credit Risk Adjustment

Q. PLEASE DISCUSS YOUR PROPOSED CREDIT RISK ADJUSTMENT.

A. SWEPCO's long-term issuer ratings are Baa2 and A- from Moody's Investors Services and S&P, respectively, compared to the average long-term issuer ratings for the Utility Proxy Group of A3 and BBB+, respectively.[65] Hence, an upward credit risk adjustment is necessary to reflect the lower credit rating, *i.e.*, Baa2, of SWEPCO relative to the A3 average Moody's bond rating of the Utility Proxy Group.[66]

An indication of the magnitude of the necessary upward adjustment to reflect the greater credit risk inherent in a Baa2 bond rating relative to the Utility Proxy Group average rating of A3 is two-thirds of a recent three-month average spread between Moody's A2 and Baa2-rated public utility bond yields of 0.41%, shown on page 4 of Schedule DWD-4, or 0.27%.[67]

C. Flotation Costs

Q. DID YOU PERFORM ANY ANALYSES RELATED TO FLOTATION COSTS IN ESTIMATING THE COMPANY'S ROE?

A. No, I did not. While flotation costs are necessary expenses associated with obtaining the capital used to finance utility assets (and, therefore, should be considered in determining the ROE), I recognize that the Commission typically has not included flotation costs in arriving at its ROE determinations. Consequently, I have not performed any analyses regarding flotation costs in this proceeding.

---

65 Source of Information: S&P Global Market Intelligence.
66 As shown on page 5 of Schedule DWD-4.

Q. WHAT IS THE INDICATED COST OF COMM COMPANY-SPECIFIC ADJUSTMENTS?

A. Applying the 0.20% size adjustment and the 0.27% credit risk adjustment, to the indicated range of common equity cost rates between 9.85% and 10.96% results in a Company-specific range of common equity rates between 10.32% and 11.43%. In consideration of both of these indicated ranges, I recommend an ROE of 10.35% for SWEPCO in this proceeding.

---

67 0.27% = 0.41% * (2/3).

X. CONCLUSION

Q. WHAT IS YOUR RECOMMENDED ROE FOR SWEPCO?

A. Given the discussion above and the results from the analyses, I recommend that an ROE of 10.35% is appropriate for the Company at this time.

Q. IN YOUR OPINION, IS YOUR PROPOSED ROE OF 10.35% FAIR AND REASONABLE TO SWEPCO AND ITS CUSTOMERS?

A. Yes, it is.

Q. IN YOUR OPINION, IS SWEPCO'S PROPOSED CAPITAL STRUCTURE CONSISTING OF 50.63% LONG-TERM DEBT AND 49.37% COMMON EQUITY FAIR AND REASONABLE?

A. Yes, it is.

Q. DOES THIS CONCLUDE YOUR DIRECT TESTIMONY?

A. Yes, it does.

SOAH DOCKET NO. 473-21-0538
PUC DOCKET NO. 51415

SOUTHWESTERN ELECTRIC POWER COMPANY'S RESPONSE TO CITIES ADVOCATING REASONABLE DEREGULATION'S THIRD SET OF REQUESTS FOR INFORMATION

Question No. CARD 3-15:

Please provide copies of Schedules DWD-1 through DWD-8 in Microsoft Excel. Please keep all data formulas embedded in the worksheet.

Response No. CARD 3-15:

Please see the Company's response to TIEC 1-37.

Prepared By: Dylan D'Ascendis | Title: Director, ScottMadden, Inc.

Sponsored By: Dylan D'Ascendis | Title: Director, ScottMadden, Inc.

SOAH DOCKET NO. 473-21-0538
PUC DOCKET NO. 51415

<u>SOUTHWESTERN ELECTRIC POWER COMPANY'S RESPONSE TO CITIES ADVOCATING REASONABLE DEREGULATION'S THIRD SET OF REQUESTS FOR INFORMATION</u>

Question No. CARD 3-16:

Please provide copies of the source documents, data and work papers associated with the development of Schedules DWD-1 through DWD-8. Please provide the underlying data and Exhibits in both paper and electronic (Microsoft Excel Worksheet) forms. For the Microsoft Excel version, please keep all formulas embedded in the worksheet.

Response No. CARD 3-16:

See the Company's response to TIEC 1-37 for the requested information.

Sponsored By: Dylan D'Ascendis Title: Director, ScottMadden, Inc.

Sponsored By: Dylan D'Ascendis Title: Director, ScottMadden, Inc.

SOAH DOCKET NO. 473-21-0538
PUC DOCKET NO. 51415

SOUTHWESTERN ELECTRIC POWER COMPANY'S RESPONSE TO CITIES ADVOCATING REASONABLE DEREGULATION'S THIRD SET OF REQUESTS FOR INFORMATION

Question No. CARD 3-17:

Please provide copies of all articles, publications, regulatory decisions, references, and/or documents cited in the testimony and/or footnotes. If the reference is a book, please provide a copy of the relevant section of the book.

Response No. CARD 3-17:

See the Company's response to TIEC 1-37 for the requested information.

Sponsored By: Dylan D'Ascendis　　Title: Director, ScottMadden, Inc.

Sponsored By: Dylan D'Ascendis　　Title: Director, ScottMadden, Inc.

SOAH DOCKET NO. 473-21-0538
PUC DOCKET NO. 51415

SOUTHWESTERN ELECTRIC POWER COMPANY'S RESPONSE TO CITIES ADVOCATING REASONABLE DEREGULATION'S THIRD SET OF REQUESTS FOR INFORMATION

Question No. CARD 3-18:

Please provide: (1) copies of the source documents, data and work papers associated with the development of Charts 1-3; and (2) the data and work papers in both paper and electronic (Microsoft Excel Worksheet) forms. For the Microsoft Excel version, please keep all formulas embedded in the worksheet.

Response No. CARD 3-18:

See the Company's response to TIEC 1-37 for the requested information.

Sponsored By: Dylan D'Ascendis	Title: Director, ScottMadden, Inc.
Sponsored By: Dylan D'Ascendis	Title: Director, ScottMadden, Inc.

SOAH DOCKET NO. 473-21-0538
PUC DOCKET NO. 51415

SOUTHWESTERN ELECTRIC POWER COMPANY'S RESPONSE TO CITIES ADVOCATING REASONABLE DEREGULATION'S THIRD SET OF REQUESTS FOR INFORMATION

Question No. CARD 3-19:

With reference to pages 18-20 of Mr. D'Ascendis' testimony, please: (1) list all companies initially considered for inclusion in the proxy group; (2) provide the data used for all companies initially considered for inclusion in the proxy group; (3) for the companies eliminated by each of the eight screens, provide the reason and/or the metric that led to the elimination from the proxy group; and (4) provide the work papers and data used in the proxy group selection process in Microsoft Excel, with all data and formulas embedded in the worksheet.

Response No. CARD 3-19:

Please see CARD 3-19 Attachment A.

Sponsored By: Dylan D'Ascendis Title: Director, ScottMadden, Inc.

Sponsored By: Dylan D'Ascendis Title: Director, ScottMadden, Inc.

Source S&P Global Market Intelligence, SEC Company 10-Ks
Numbers in ($000)

(as of July 31, 2020)

	NOI	NOI Regulated Electric	% Regulated Electric	Assets	Assets Regulated Electric	% Regulated Electric	Both NOI and Assets >= 70% Regulated Electric	Merger / Significant Event?	Dividend Cutter?	VL / BB betas?	Positive VL DPS Growth Projections?	VL, Zacks, or Yahoo Proj EPS Growth Rates?	Vertically Integrated	Proxy Group Company?
ALE	255,500	208,800	81.72%	4,377,000	3,255,400	74.38%	Y	N	N	Y	Y	Y	Y	Y
LNT	777,700	678,900	87.30%	16,700,700	13,659,000	81.79%	Y	N	N	Y	Y	Y	Y	Y
AEE	1,209,000	1,055,043	87.27%	36,652,000	30,698,000	83.76%	Y	N	N	Y	Y	Y	Y	Y
AEP	2,592,300	2,523,000	97.33%	75,892,300	71,129,800	93.72%	Y	Y	N	Y	Y	Y	Y	N
AGR	2,071,000	745,993	36.02%	19,479,000	15,092,000	77.48%	N	N	N	Y	Y	Y	Y	N
AVA	534,311	334,300	62.57%	6,627,934	4,951,631	74.71%	N	N	N	Y	Y	Y	Y	N
BKH	406,042	160,297	39.48%	7,558,457	2,900,983	38.38%	N	N	N	Y	Y	Y	Y	N
CNP	1,226,000	714,000	58.24%	35,439,000	14,432,000	40.72%	N	N	Y	Y	N	Y	N	N
CMS	1,239,000	806,000	65.05%	26,837,000	14,911,000	55.56%	N	N	N	Y	Y	Y	Y	N
ED	2,676,000	1,856,000	69.36%	57,709,000	35,118,000	60.85%	N	N	N	Y	Y	Y	N	N
D	2,635,000	3,577,000	135.75%	103,800,000	59,500,000	57.32%	N	N	Y	Y	Y	Y	Y	N
DTE	1,712,000	1,135,000	66.30%	41,882,000	24,617,000	58.78%	N	N	N	Y	Y	Y	Y	N
DUK	5,709,000	5,313,000	93.06%	158,838,000	135,561,000	85.35%	Y	N	N	Y	Y	Y	Y	Y
EIX	1,284,000	1,409,000	109.74%	NA	NA	100.00%	Y	N	N	Y	Y	Y	Y	Y
ETR	4,013,157	3,025,721	75.40%	58,319,049	54,271,467	93.06%	Y	N	N	Y	Y	Y	Y	Y
EVRG	NA	NA	100.00%	NA	NA	100.00%	Y	Y	N	Y	Y	Y	Y	N
EXC	10,158,000	5,274,116	51.92%	104,212,000	86,648,000	83.15%	N	N	N	Y	Y	Y	Y	N
FE	2,672,000	1,921,000	71.89%	42,301,000	29,642,000	70.07%	Y	Y	N	Y	Y	Y	Y	N
HE	348,674	254,378	72.96%	13,745,251	6,388,682	46.48%	N	N	N	Y	Y	Y	Y	N
IDA	298,326	297,652	99.77%	6,641,201	6,494,159	97.79%	Y	N	N	Y	Y	Y	Y	Y
MGEE	110,910	59,180	53.36%	2,081,664	1,308,277	62.85%	N	N	N	Y	Y	Y	Y	N
NEE	5,353,000	3,573,000	66.75%	117,691,000	63,043,000	53.57%	N	N	N	Y	Y	Y	Y	N
ES	1,590,500	1,285,000	80.79%	41,123,900	33,445,900	81.33%	Y	N	N	Y	Y	Y	N	N
NWE	276,850	231,217	83.52%	5,910,702	4,685,990	79.28%	Y	N	N	Y	Y	Y	Y	Y
OGE	504,300	507,700	100.67%	11,024,300	10,076,600	91.40%	Y	N	N	Y	Y	Y	Y	Y
OTTR	134,880	98,417	72.97%	2,273,595	1,931,525	84.95%	Y	N	N	Y	Y	Y	Y	Y
PNW	NA	NA	100.00%	NA	NA	100.00%	Y	N	N	Y	Y	Y	Y	Y
PNM	144,200	146,882	101.86%	7,298,774	7,103,430	97.32%	Y	N	N	Y	Y	Y	Y	Y
POR	NA	NA	100.00%	NA	NA	100.00%	Y	N	N	Y	Y	Y	Y	Y
PPL	752,000	392,209	52.16%	45,680,000	23,582,883	51.63%	N	N	N	Y	Y	Y	Y	N
PEG	2,200,000	965,941	43.91%	33,900,000	22,163,000	65.38%	N	N	N	Y	Y	Y	N	N
SRE	3,214,000	1,548,614	48.18%	49,329,000	18,469,000	37.44%	N	N	N	Y	Y	Y	Y	N
SO	4,739,000	2,929,000	61.81%	118,700,000	81,063,000	68.29%	N	N	N	Y	Y	Y	Y	N
WEC	4,721,400	2,975,700	63.03%	31,653,600	13,876,900	43.84%	N	N	N	Y	Y	Y	Y	N
XEL	1,372,000	1,288,000	93.88%	55,844,000	44,355,000	79.43%	Y	N	N	Y	Y	Y	Y	Y

SOAH Docket No 473-21-0538
PUC Docket No 51415
CARD's 3rd, Q # CARD 3-19
Attachment A

SOAH DOCKET NO. 473-21-0538
PUC DOCKET NO. 51415

SOUTHWESTERN ELECTRIC POWER COMPANY'S RESPONSE TO CITIES ADVOCATING REASONABLE DEREGULATION'S THIRD SET OF REQUESTS FOR INFORMATION

Question No. CARD 3-20:

With reference to pages 28-41 of Mr. D'Ascendis' testimony and Schedule DVD-4, please provide: (1) copies of all data and show all computations and supply source documents and work papers used so that the following items for each company (as shown on pages 8, 12 and 13 of Schedule DVD-4) can be duplicated - (a) GARCH, (b) Average Variance, and (c) PRPM Derived Risk Premium; and (2) copies of the data, calculations, source documents, and work papers, in both hard copy and electronic (Microsoft Excel) formats, with all data and formulas intact.

Response No. CARD 3-20:

See the response to TIEC 1-37 for the computation of the average and spot variances and Mr. D'Ascendis' Workpaper 26 provided in the Company's rate filing package for the source documents showing the GARCH equations for each security. The average predicted variances, the spot variances, and the GARCH coefficients were generated by applying the GARCH model to the historical monthly return data shown in Excel tabs "PRPM WP 3" through "PRPM WP 19" in Mr. D'Ascendis' Excel workpapers provided in response to TIEC 1-37. The data shown on Excel Tab "PRPM WP 1" is directly exported from EViews®, a type of statistical software, without any modification.

Sponsored By: Dylan D'Ascendis Title: Director, ScottMadden, Inc.

Sponsored By: Dylan D'Ascendis Title: Director, ScottMadden, Inc.

SOAH DOCKET NO. 473-21-0538
PUC DOCKET NO. 51415

SOUTHWESTERN ELECTRIC POWER COMPANY'S RESPONSE TO CITIES ADVOCATING REASONABLE DEREGULATION'S THIRD SET OF REQUESTS FOR INFORMATION

Question No. CARD 3-21:

With reference to pages 28-41 of Mr. D'Ascendis' testimony and Schedule DVD-4, please: (1) list all regulatory cases (by utility name, docket number, and filing date) in which Mr. D'Ascendis has provided rate of return testimony and used his PRPM approach to estimating a market risk premium; (2) indicate all cases (by name, docket number, and date) a regulatory commission has adopted Mr. D'Ascendis' PRPM approach in arriving at risk premium and overall rate of return for a utility; and (3) provide copies of the 'Rate of Return' section of the Commission's decisions for all cases in which a regulatory commission has adopted the PRPM approach.

Response No. CARD 3-21:

1. Please see CARD 3-21 Attachment A for Mr. D'Ascendis' list of regulatory cases in which he has provided rate of return testimony. In each of those proceedings, Mr. D'Ascendis presented the PRPM as a measure of a predicted risk premium.
2. In Mr. D'Ascendis' experience, most Commission Orders are silent on results of individual models and certainly on aspects of individual models (PRPM is used in portions of the risk premium model and capital asset pricing model applied to both the utility and the non-utility group). In Docket No. 2017-292-WS, concerning Carolina Water Service, Inc., the Public Service Commission accepted Mr. D'Ascendis' entire position regarding the cost of capital, including the use of the PRPM. The relevant portion states:

> The Commission finds Mr. D'Ascendis' arguments persuasive. He provided more indicia of market returns, by using more analytical methods and proxy group calculations. Mr. D'Ascendis' use of analysts' estimates for his DCF analysis is supported by consensus, as is his use of the arithmetic mean. The Commission also finds that Mr. D'Ascendis' non-price regulated proxy group more accurately reflects the total risk faced price regulated utilities and CWS. Furthermore, there is no dispute that CWS is significantly smaller than its proxy group counterparts, and, therefore, it may present a higher risk. An appropriate ROE for CWS is 10.45% to 10.95%. The Company used an ROE of 10.5% in computing its Application, a return on the low end of Mr. D'Ascendis' range, and the Commission finds that ROE is supported by the evidence.

3. Please see CARD 3-21 Attachment B.

Sponsored By: Dylan D'Ascendis Title: Director, ScottMadden, Inc.

Sponsored By: Dylan D'Ascendis Title: Director, ScottMadden, Inc.

Summary

Dylan is an experienced consultant and a Certified Rate of Return Analyst (CRRA) and Certified Valuation Analyst (CVA) He has served as a consultant for investor-owned and municipal utilities and authorities for 12 years. Dylan has extensive experience in rate of return analyses, class cost of service, rate design, and valuation for regulated public utilities He has testified as an expert witness in the subjects of rate of return, cost of service, rate design, and valuation before 23 regulatory commissions in the U S , one Canadian province, and an American Arbitration Association panel.

He also maintains the benchmark index against which the Hennessy Gas Utility Mutual Fund performance is measured.

Areas of Specialization

- Regulation and Rates
- Utilities
- Mutual Fund Benchmarking
- Capital Market Risk
- Financial Modeling
- Valuation
- Regulatory Strategy
- Rate Case Support
- Rate of Return
- Cost of Service
- Rate Design

Recent Expert Testimony Submission/Appearances

Jurisdiction	Topic
Massachusetts Department of Public Utilities	Rate of Return
New Jersey Board of Public Utilities	Rate of Return
Hawaii Public Utilities Commission	Cost of Service, Rate Design
South Carolina Public Service Commission	Return on Common Equity
American Arbitration Association	Valuation

Recent Assignments

- Provided expert testimony on the cost of capital for ratemaking purposes before numerous state utility regulatory agencies
- Maintains the benchmark index against which the Hennessy Gas Utility Mutual Fund performance is measured
- Sponsored valuation testimony for a large municipal water company in front of an American Arbitration Association Board to justify the reasonability of their lease payments to the City
- Co-authored a valuation report on behalf of a large investor-owned utility company in response to a new state regulation which allowed the appraised value of acquired assets into rate base

Recent Publications and Speeches

- Co-Author of: "Decoupling, Risk Impacts and the Cost of Capital", co-authored with Richard A Michelfelder, Ph D., Rutgers University and Pauline M. Ahern The Electricity Journal, March, 2020.
- Co-Author of. "Decoupling Impact and Public Utility Conservation Investment", co-authored with Richard A. Michelfelder, Ph.D., Rutgers University and Pauline M Ahern Energy Policy Journal, 130 (2019), 311-319.
- "Establishing Alternative Proxy Groups", before the Society of Utility and Regulatory Financial Analysts 51st Financial Forum, April 4, 2019, New Orleans, LA
- "Past is Prologue: Future Test Year", Presentation before the National Association of Water Companies 2017 Southeast Water Infrastructure Summit, May 2, 2017, Savannah, GA
- Co-author of. "Comparative Evaluation of the Predictive Risk Premium Model™, the Discounted Cash Flow Model and the Capital Asset Pricing Model", co-authored with Richard A Michelfelder, Ph.D , Rutgers University, Pauline M. Ahern, and Frank J. Hanley, The Electricity Journal, May, 2013
- "Decoupling. Impact on the Risk and Cost of Common Equity of Public Utility Stocks", before the Society of Utility and Regulatory Financial Analysts 45th Financial Forum, April 17-18, 2013, Indianapolis, IN

SPONSOR	DATE	CASE/APPLICANT	DOCKET NO.	SUBJECT
Regulatory Commission of Alaska				
Alaska Power Company	09/20	Alaska Power Company, Goat Lake Hydro, Inc.; BBL Hydro, Inc.	Tariff Nos. TA886-2, TA6-521, TA4-573	Capital Structure
Alaska Power Company	07/16	Alaska Power Company	Docket No. TA857-2	Rate of Return
Alberta Utilities Commission				
AltaLink, L.P., and EPCOR Distribution & Transmission, Inc.	01/20	AltaLink, L.P., and EPCOR Distribution & Transmission, Inc.	2021 Generic Cost of Capital, Proceeding ID. 24110	Rate of Return
Arizona Corporation Commission				
EPCOR Water Arizona, Inc.	06/20	EPCOR Water Arizona, Inc.	Docket No. WS-01303A-20-0177	Rate of Return
Arizona Water Company	12/19	Arizona Water Company – Western Group	Docket No. W-01445A-19-0278	Rate of Return
Arizona Water Company	08/18	Arizona Water Company – Northern Group	Docket No. W-01445A-18-0164	Rate of Return
Colorado Public Utilities Commission				
Summit Utilities, Inc.	04/18	Colorado Natural Gas Company	Docket No. 18AL-0305G	Rate of Return
Atmos Energy Corporation	06/17	Atmos Energy Corporation	Docket No 17AL-0429G	Rate of Return
Delaware Public Service Commission				
Delmarva Power & Light Co.	10/20	Delmarva Power & Light Co.	Docket No. 20-0150	Rate of Return
Tidewater Utilities, Inc.	11/13	Tidewater Utilities, Inc	Docket No 13-466	Capital Structure
Public Service Commission of the District of Columbia				
Washington Gas Light Company	09/20	Washington Gas Light Company	Formal Case No 1162	Rate of Return
Florida Public Service Commission				
Peoples Gas System	09/20	Peoples Gas System	Docket No. 20200051-GU	Rate of Return
Utilities, Inc. of Florida	06/20	Utilities, Inc. of Florida	Docket No. 20200139-WS	Rate of Return
Hawaii Public Utilities Commission				
Lanai Water Company, Inc.	12/19	Lanai Water Company, Inc	Docket No. 2019-0386	Cost of Service / Rate Design
Manele Water Resources, LLC	08/19	Manele Water Resources, LLC	Docket No. 2019-0311	Cost of Service / Rate Design
Kaupulehu Water Company	02/18	Kaupulehu Water Company	Docket No. 2016-0363	Rate of Return
Aqua Engineers, LLC	05/17	Puhi Sewer & Water Company	Docket No 2017-0118	Cost of Service / Rate Design
Hawaii Resources, Inc.	09/16	Laie Water Company	Docket No. 2016-0229	Cost of Service / Rate Design
Illinois Commerce Commission				
Ameren Illinois Company d/b/a Ameren Illinois	07/20	Ameren Illinois Company d/b/a Ameren Illinois	Docket No 20-0308	Return on Equity
Utility Services of Illinois, Inc.	11/17	Utility Services of Illinois, Inc.	Docket No. 17-1106	Cost of Service / Rate Design
Aqua Illinois, Inc.	04/17	Aqua Illinois, Inc.	Docket No 17-0259	Rate of Return
Utility Services of Illinois, Inc.	04/15	Utility Services of Illinois, Inc.	Docket No. 14-0741	Rate of Return
Indiana Utility Regulatory Commission				

SPONSOR	DATE	CASE/APPLICANT	DOCKET NO.	SUBJECT
Aqua Indiana, Inc	03/16	Aqua Indiana, Inc Aboite Wastewater Division	Docket No. 44752	Rate of Return
Twin Lakes, Utilities, Inc.	08/13	Twin Lakes, Utilities, Inc.	Docket No. 44388	Rate of Return
Kansas Corporation Commission				
Atmos Energy	07/19	Atmos Energy	19-ATMG-525-RTS	Rate of Return
Louisiana Public Service Commission				
Atmos Energy	04/20	Atmos Energy	Docket No. U-35535	Rate of Return
Louisiana Water Service, Inc.	06/13	Louisiana Water Service, Inc.	Docket No. U-32848	Rate of Return
Maryland Public Service Commission				
Washington Gas Light Company	08/20	Washington Gas Light Company	Case No. 9651	Rate of Return
FirstEnergy, Inc.	08/18	Potomac Edison Company	Case No. 9490	Rate of Return
Massachusetts Department of Public Utilities				
Unitil Corporation	12/19	Fitchburg Gas & Electric Co. (Elec.)	D.P.U. 19-130	Rate of Return
Unitil Corporation	12/19	Fitchburg Gas & Electric Co. (Gas)	D.P.U. 19-131	Rate of Return
Liberty Utilities	07/15	Liberty Utilities d/b/a New England Natural Gas Company	Docket No. 15-75	Rate of Return
Mississippi Public Service Commission				
Atmos Energy	03/19	Atmos Energy	Docket No. 2015-UN-049	Capital Structure
Atmos Energy	07/18	Atmos Energy	Docket No 2015-UN-049	Capital Structure
Missouri Public Service Commission				
Indian Hills Utility Operating Company, Inc.	10/17	Indian Hills Utility Operating Company, Inc.	Case No. SR-2017-0259	Rate of Return
Raccoon Creek Utility Operating Company, Inc.	09/16	Raccoon Creek Utility Operating Company, Inc.	Docket No. SR-2016-0202	Rate of Return
Public Utilities Commission of Nevada				
Southwest Gas Corporation	08/20	Southwest Gas Corporation	Docket No. 20-02023	Return on Equity
New Jersey Board of Public Utilities				
FirstEnergy	02/20	Jersey Central Power & Light Co.	Docket No ER20020146	Rate of Return
Aqua New Jersey, Inc.	12/18	Aqua New Jersey, Inc.	Docket No. WR18121351	Rate of Return
Middlesex Water Company	10/17	Middlesex Water Company	Docket No. WR17101049	Rate of Return
Middlesex Water Company	03/15	Middlesex Water Company	Docket No. WR15030391	Rate of Return
The Atlantic City Sewerage Company	10/14	The Atlantic City Sewerage Company	Docket No. WR14101263	Cost of Service / Rate Design
Middlesex Water Company	11/13	Middlesex Water Company	Docket No. WR1311059	Capital Structure
North Carolina Utilities Commission				
Duke Energy Carolinas, LLC	07/20	Duke Energy Carolinas, LLC	Docket No. E-7, Sub 1214	Return on Equity
Duke Energy Progress, LLC	07/20	Duke Energy Progress, LLC	Docket No E-2, Sub 1219	Return on Equity
Aqua North Carolina, Inc	12/19	Aqua North Carolina, Inc	Docket No W-218 Sub 526	Rate of Return
Carolina Water Service, Inc.	06/19	Carolina Water Service, Inc	Docket No. W-354 Sub 364	Rate of Return
Carolina Water Service, Inc.	09/18	Carolina Water Service, Inc.	Docket No. W-354 Sub 360	Rate of Return
Aqua North Carolina, Inc.	07/18	Aqua North Carolina, Inc.	Docket No. W-218 Sub 497	Rate of Return

SPONSOR	DATE	CASE/APPLICANT	DOCKET NO.	SUBJECT
Public Utilities Commission of Ohio				
Aqua Ohio, Inc.	05/16	Aqua Ohio, Inc.	Docket No. 16-0907-WW-AIR	Rate of Return
Pennsylvania Public Utility Commission				
Valley Energy, Inc.	07/19	C&T Enterprises	Docket No. R-2019-3008209	Rate of Return
Wellsboro Electric Company	07/19	C&T Enterprises	Docket No. R-2019-3008208	Rate of Return
Citizens' Electric Company of Lewisburg	07/19	C&T Enterprises	Docket No. R-2019-3008212	Rate of Return
Steelton Borough Authority	01/19	Steelton Borough Authority	Docket No. A-2019-3006880	Valuation
Mahoning Township, PA	08/18	Mahoning Township, PA	Docket No. A-2018-3003519	Valuation
SUEZ Water Pennsylvania Inc.	04/18	SUEZ Water Pennsylvania Inc.	Docket No. R-2018-000834	Rate of Return
Columbia Water Company	09/17	Columbia Water Company	Docket No. R-2017-2598203	Rate of Return
Veolia Energy Philadelphia, Inc.	06/17	Veolia Energy Philadelphia, Inc	Docket No R-2017-2593142	Rate of Return
Emporium Water Company	07/14	Emporium Water Company	Docket No. R-2014-2402324	Rate of Return
Columbia Water Company	07/13	Columbia Water Company	Docket No. R-2013-2360798	Rate of Return
Penn Estates Utilities, Inc.	12/11	Penn Estates, Utilities, Inc.	Docket No. R-2011-2255159	Capital Structure / Long-Term Debt Cost Rate
South Carolina Public Service Commission				
Blue Granite Water Co.	12/19	Blue Granite Water Company	Docket No. 2019-292-WS	Rate of Return
Carolina Water Service, Inc.	02/18	Carolina Water Service, Inc.	Docket No. 2017-292-WS	Rate of Return
Carolina Water Service, Inc.	06/15	Carolina Water Service, Inc	Docket No. 2015-199-WS	Rate of Return
Carolina Water Service, Inc.	11/13	Carolina Water Service, Inc.	Docket No 2013-275-WS	Rate of Return
United Utility Companies, Inc.	09/13	United Utility Companies, Inc.	Docket No. 2013-199-WS	Rate of Return
Utility Services of South Carolina, Inc.	09/13	Utility Services of South Carolina, Inc.	Docket No. 2013-201-WS	Rate of Return
Tega Cay Water Services, Inc.	11/12	Tega Cay Water Services, Inc.	Docket No. 2012-177-WS	Capital Structure
Tennessee Public Utility Commission				
Piedmont Natural Gas Company	07/20	Piedmont Natural Gas Company	Docket No. 20-00086	Return on Equity
Virginia State Corporation Commission				
Aqua Virginia, Inc.	07/20	Aqua Virginia, Inc.	PUR-2020-00106	Rate of Return
WGL Holdings, Inc.	07/18	Washington Gas Light Company	PUR-2018-00080	Rate of Return
Atmos Energy Corporation	05/18	Atmos Energy Corporation	PUR-2018-00014	Rate of Return
Aqua Virginia, Inc.	07/17	Aqua Virginia, Inc.	PUR-2017-00082	Rate of Return
Massanutten Public Service Corp.	08/14	Massanutten Public Service Corp.	PUE-2014-00035	Rate of Return / Rate Design

BEFORE

THE PUBLIC SERVICE COMMISSION OF

SOUTH CAROLINA

DOCKET NO. 2017-292-WS - ORDER NO. 2018-345

MAY 17, 2018

IN RE:	Application of Carolina Water Service, Inc. for Adjustment of Rates and Charges and Modification to Certain Terms and Conditions for the Provision of Water and Sewer Service	)	ORDER APPROVING RATES AND CHARGES

This matter is before the Public Service Commission of South Carolina ("Commission") on the Application of Carolina Water Service, Inc. ("CWS" or "Company") for approval of a new schedule of rates and charges and modifications to certain terms and conditions for the provision of water and sewer services for its customers in South Carolina. CWS filed its Application on November 10, 2017, pursuant to S.C. Code § 58-5-240 and S.C. Code Regs. §§ 103-503, 103-703, 103-512.4.A and 103-712.4.A.

In the Application, CWS requested an increase in revenues for combined operations of $4,511,414 consisting of a water revenue increase of $2,272,914 and a sewer revenue increase of $2,238,500. The revenue increase utilizes a return on equity ("ROE") of 10.5% based on the rate of return on rate base methodology and a historical test year beginning September 1, 2016, and ending August 31, 2017.

CWS requested permission to modify its sewer service tariff to reduce the frequency with which customers must test their backflow devices from every year to every two years, and to authorize the Company to terminate service, after notice, to a customer who fails to demonstrate that his backflow device is working properly. App. p. 6, ¶ 20. CWS requested authorization to increase its Water Meter Installation Charge from $35 to $45 per year, to more accurately reflect the utility's cost of providing this service. App. p. 6, ¶ 21. The Company also requested approval of a provision in its tariff limiting the liability of the Company, its agents, and employees for interruption of service, whether caused by acts or omissions, to those remedies provided in the Commission's rules and regulations. App. p. 6, ¶ 22.

CWS last rate case before this Commission was in Docket No. 2015-199-WS. In that case, the Commission approved a settlement in which CWS received a combined revenue increase of $3,068,441 based on a $50,955,443 rate base; an operating margin of 11.95%, an ROE of 9.34%, and a return on rate base of 7.99%.

CWS' South Carolina operations are classified by the National Association of Regulatory Utility Commissioners ("NARUC") as a Class A water and wastewater utility according to water and sewer revenues reported on its Application for the test year ending August 31, 2017. The Commission's approved service area for CWS is in parts of sixteen counties.

I. PROCEDURAL BACKGROUND

The Commission's Clerk's Office instructed CWS to publish a prepared Notice of Filing, one time, in a newspaper of general circulation in the area affected by CWS' Application and to mail copies of the Notice of Filing to all customers affected by the proposed rates and charges and modifications. The Notice of Filing indicated the nature of the Application and advised all interested parties desiring to participate in the scheduled proceeding of the manner and time in which to file the appropriate pleadings. CWS filed affidavits demonstrating the Notice of Filing had been duly published and provided to all customers.

Petitions to Intervene were subsequently filed on behalf of the Forty Love Point Homeowners' Association ("Forty Love"), York County, and James S. Knowlton. The South Carolina Office of Regulatory Staff ("ORS"), a party of record pursuant to S.C. Code § 58-4-10(B), made on-site investigations of CWS' facilities, audited CWS' books and records, issued data requests, and gathered other detailed information concerning CWS' operations.

CWS was represented by Charles L.A. Terreni, and Scott Elliott. Laura P. Valtorta represented Forty Love. Michael K. Kendree represented York County, Mr. Knowlton appeared pro se. Jeffrey M. Nelson, and Florence P. Belser represented the ORS. On March 28, 2018 York County moved to withdraw from the proceedings without prejudice after CWS withdrew its request for approval of the Utility System Improvement Rate ("USIR"). York County's request was granted on the same day. Order No. 2018-38-H.

The Commission held public hearings in Lexington, York, and Greenville counties to allow CWS's customers to present their views regarding the Application. An evidentiary hearing was held April 3-4, 2018, at the Commission's offices in Columbia with the Honorable Swain E. Whitfield, presiding.

The Company presented the testimony of Michael R. Cartin, Operations and Regulatory Affairs Manager (direct, rebuttal and supplemental), Robert M. Hunter, Financial Planning and Analysis Manager (direct and rebuttal), and Bob Gilroy, Vice President of Operations (direct, rebuttal, and testimony responsive to customers who testified at public hearings). Mr. Cartin, testified about the Company's operations and various expenses and capital expenditures made by CWS. Mr. Hunter testified about the Company's finances and revenue requirement, and Mr. Gilroy testified about various aspects of the Company's operations and customer service. The Company also presented the testimony of Dylan W. D'Ascendis, CRRA, Director at ScottMadden, Inc., who testified to the Company's capital structure, cost of debt, and recommended ROE.

Forty Love presented the direct testimony of subdivision residents and customers Barbara King and Jay Dixon. They testified to problems experienced with the sewer system serving Forty Love Point. Mr. Knowlton presented his rebuttal testimony opposing the amount and frequency of the Company's rate increases.

ORS presented the testimony of Matthew Schellinger (direct and surrebuttal), Zachary Payne (direct and surrebuttal), and Douglas H. Carlisle, Jr., Ph.D. (direct and surrebuttal) as a panel. Dr. Carlisle testified to the Company's capital structure, cost of debt, and recommended ROE.

Dr. Carlisle's testimony included an analysis and recommendation for an allowed ROE. Mr. Payne testified about ORS's examination of the Application and CWS' books and records and the subsequent accounting and pro forma adjustments recommended by ORS. Mr. Schellinger's direct testimony focused on CWS' compliance with Commission rules and regulations, ORS' business office compliance review, inspections of CWS' water and wastewater systems, test year and proposed revenue, and performance bond requirements.

II. REVIEW OF THE EVIDENCE AND EVIDENTIARY CONCLUSIONS

A. Standards and Required Findings

In considering the Application, the Commission must ascertain and fix just and reasonable rates, standards, classifications, regulations, practices, and measurements of service to be furnished. The Commission must give due consideration to the Company's total revenue requirements and review the operating revenues and operating expenses of CWS to establish adequate and reasonable levels of revenues and expenses. The Commission will consider a fair rate of return for CWS based on the record and any increase must be just and reasonable and free of undue discrimination. CWS has also asked this Commission to approve revenues based on an authorized ROE established to allow CWS the opportunity to earn a fair return.

After evaluation of the positions of the parties, the Commission reaches the legal and factual conclusions discussed below, based on its review of the facts and evidence of record. The evidence supporting the Company's business and legal status is contained in the Application filed by CWS, testimony, and in prior Commission orders in the docket files of the Commission, of which the Commission takes judicial notice.

CWS has approximately 16,000 water customers and 14,000 sewer customers in Lexington, Richland, Sumter, Aiken, Saluda, Orangeburg, Beaufort, Georgetown, Abbeville, Union, Anderson, York, Cherokee, Greenville, Greenwood, and Williamsburg counties. App. Schd. F; R. p. 345 (Gilroy Dir. p. 2, ll. 21-24). As a public utility, its operations are subject to the jurisdiction of the Commission pursuant to S.C. Code §§ 58-5-10 et seq.

B. Test Year

A fundamental principle of the ratemaking process is the establishment of a historical test year as the basis for calculating a utility's return on rate base. To determine the utility's expenses and revenues, we must select a 'test year' for the measurement of the expenses and revenues. Heater of Seabrook v. PSC, 324 S.C. 56, 59 n.1 (1996). While the Commission considers a utility's proposed rate increase based upon occurrences within the test year, the Commission will also consider adjustments for any known and measurable out-of-test year changes in expenses, revenues, and investments, and will also consider adjustments for any unusual situations which occurred in the test year. When the test year figures are atypical, the Commission should adjust the test year data. See S. Bell Tel. & Tel. Co. v. Pub. Serv. Com, 270 S.C. 590, 603 (1978).

In its Application, CWS utilized a historic test year, the twelve months beginning September 1, 2016, and ending August 31, 2017, with adjustments for 2018 expectations. App. p.2, ¶ 5. ORS used the same historical test year. R. p. 729 (Payne Dir. p. 2, ll. 5-10). None of the other parties contested CWS' proposed test year. Based on the information available to the Commission, and that none of the parties objected to CWS' proposed test year, the Commission concludes that the test year beginning September 1, 2016, and ending August 31, 2017, is appropriate for this Application.

C. Rate of Return on Rate Base

The Company requested rate base and rate of return treatment for its Application. App. pp. 4-5, ¶ 16. No other party of record proposed an alternative method for determining just and reasonable rates and the testimony of ORS' witnesses Payne and Carlisle assumes that return on rate base will be the methodology employed.

The Commission has wide latitude in selecting a rate setting methodology. Heater of Seabrook, at 64. Even though S.C. Code § 58-5-240(H) requires the Commission to specify an operating margin in all water and sewer rate cases, the Commission is not precluded by that statute from employing the return on rate base approach to ratemaking. Id. Operating margin "is less appropriate for utilities that have large rate bases and need to earn a rate of return sufficient to obtain the necessary debt and equity capital that a large utility needs for sound operation." Id at 65. In the Company's last rate case, the Commission employed the return on rate base methodology. The Commission finds the return on rate base methodology is appropriate. The Company's rate base, according to its Application, is $54,853,170. App. Ex. B, Sch. C, p. 1.

The determination of return on rate base requires consideration of three components, namely: capital structure, cost of equity (or "ROE") and the cost of debt. R. pp. 397-398 (D' Ascendis Dir. pp. 4-5).

Mr. D'Ascendis and Dr. Carlisle agreed the capital structure and cost of debt of CWS's parent, Utilities, Inc. should be employed: it is 48.11% long-term debt and 51.89% common equity. R. pp. 395 (D'Ascendis Dir. p. 2, ll. 10-17); 649 (Carlisle Dir. p.4, ll. 21-

p.5, l. 3). No other party disagreed. The Commission finds this capital structure supported by the uncontroverted testimony of the parties.

Mr. D'Ascendis and Dr. Carlisle disagreed on CWS's cost of debt. Mr. D'Ascendis used an embedded debt rate of 6.60%. Dr. Carlisle lowered CWS's cost of debt rate from 6.60% to 6.58% due to what he described as "unfavorable terms" of the Company's long-term debt. R. p. 649 (Carlisle Dir., p. 4, l. 21 – p. 5, l. 9). Dr. Carlisle argued the Company imprudently refinanced its long-term debt when interest rates were high and agreed to terms which prevent it from refinancing now that interest rates are lower. Id. Mr. D' Ascendis countered that the Company's long-term debt financing, which was agreed to in 2006, was in line with bond yields for similarly situated companies at the time. R. p. 438 (D'Ascendis, Rebut. p. 3, ll. 1-14). However, the Commission has not been provided any evidence to support the ORS position. We find the appropriate long-term debt rate for CWS is 6.60%.

The rate of return on common equity, or ROE, is a key figure used in calculating a utility's overall rate of return. Porter v. PSC, 333 S.C. 12 (1998). A utility is entitled to the opportunity to earn a fair rate of return. Federal Power Commission v. Hope Natural Gas Co., 320 U.S. 591 (1944) and Bluefield Water Works Improvement Co. v. Public Service Comm'n, 262 U.S. 679 (1922),

Mr. D'Ascendis recommended that CWS' ROE should fall within a range of 10.45% to 10.95%. R. p. 397 (D'Ascendis Dir. p. 4, ll. 4-20 (Table 2)).

To determine the cost of equity, Mr. D'Ascendis used the Discounted Cash Flow ("DCF") Risk Premium Model ("RPM") and the Capital Asset Pricing Model ("CAP-M") and ("ECAP-M") model to similar risk companies, i.e. proxy groups, of regulated and non-regulated companies. R. pp. 396-397 (D'Ascendis Direct pp. 3-4).

The proxy groups were used by Mr. D'Ascendis because the Company's common stock is not publicly traded, and, therefore, CWS's market-based common equity cost rates cannot be determined directly. Id. He used a proxy group of eight water companies whose common stocks were actively traded for insight into a common equity cost rate applicable to CWS. R. p. 402 (D'Ascendis Direct, p.10). The utility proxy group was selected according to these criteria: 1) they are included in the Water Utility Group of Value Line's Standard Edition (October 13, 2017); 2) they have 70% or greater of 2016 total operating income and 70% or greater of 2016 total assets attributable to regulated water operations; 3) at the time of the preparation of this testimony, they had not publicly announced that they were involved in any major merger or acquisition activity (i.e. one publicly traded utility merging with or acquiring another); 4) they have not cut or omitted their common dividends during the five years ending 2016 or through the time of the preparation of this testimony; 5) they have Value Line and Bloomberg adjusted betas; 6) they have a positive Value Line five-year dividends per share ("DPS") growth rate projection; and 7) they have Value Line, Reuters, Zacks, or Yahoo! Finance consensus five-year earnings per share ("EPS") growth rate projections. Id. The companies that met Mr. D'Ascendis' criteria were: American States Water Co., American Water Works Co., Inc., Aqua America, Inc., California Water Service Group, Connecticut Water Service, Inc., Middlesex Water Co., SJW Corp., and York Water Co. Id.

Mr. D'Ascendis also selected a proxy group of twenty-eight non-price regulated companies comparable in total risk to the proxy group of water companies. R. Ex. 8 (D'Ascendis Direct, Ex. 1, Schd. DWD-6). The criteria for non-price regulated proxy group were: 1) they must be covered by Value Line Investment Survey (Standard Edition); 2) they must be domestic, non-price regulated companies, i.e., non-utilities; 3) their beta coefficients must lie within plus or minus two standard deviations of the average unadjusted beta of the utility proxy group; and 4) the residual standard errors of the Value Line regressions, which gave rise to the unadjusted beta coefficients, must lie within plus or minus two standard deviations of the average residual standard error of the utility proxy group. R, p. 423 (D'Ascendis Direct, p. 30, ll. 15-23).

Mr. D'Ascendis' DCF analysis yields cost rates for the water company proxy group of 8.64%. The RPM analysis produced a common equity cost rate of 10.69% for the water company proxy group. The CAP-M cost rate is 10.51% for the water company proxy group. D'Ascendis averaged the mean, 10.43%, and median, 10.58%, equity costs of the water company proxy group, resulting in 10.51%. R. p. 424 (D'Ascendis Direct, p. 29, ll. 10-15). With the non-price regulated proxy group, the DCF yields 13.57%, the RPM, 11.91%, and the CAP-M/ECAP-M, 11.15%. R. p. 424 (D'Ascendis Direct, pp. 31, l. 12-32, l. 4). The average of the mean and median of the non-price regulated proxy group is 12.06%. R. p. 425 (D'Ascendis Direct, p. 32, ll. 7-14).

The approximate average of the results produced by any of Mr. D'Ascendis' models is 10.45%. R. p. 426 (D'Ascendis Direct, p. 33, ll. 5-9). He also recommended an upward adjustment of 0.50% ROE, due to CWS's small size. R. pp. 426 - 429 (D'Ascendis Direct,

p. 33, l. 11- 36, l. 20). His average ROE after the size adjustment is 10.95%. R. p. 429 (D'Ascendis Direct, p. 36, ll. 17-20). Mr. D'Ascendis recommended range of ROE was 10.45% to 10.95%. R. p. 397 (D'Ascendis Dir. p. 4, ll. 4-20 (Table 2)).

Dr. Carlisle employed the DCF model, the Comparable Earnings Model ("CEM"), and the CAP-M method to calculate his ROE range of 8.82% to 9.54%. R. p. 647 (Carlisle Direct, p. 2, ll. 12-15).

Dr. Carlisle also used a water company proxy group of ten water companies for his DCF and CAP-M analyses. R. p. 649 (Carlisle Direct, p. 4, ll. 15-20). Dr. Carlisle's water company proxy group was identical to Mr. D'Ascendis' water company proxy group except for the addition of Global Water Resources and Artesian Resources. Carlisle Rev. Exhibit DHC-4.

Dr. Carlisle's DCF analysis yields cost rates for his water company proxy group of 8.82%. R. p. 654 (Carlisle Direct, p. 9, ll. 5-6). Dr. Carlisle did not perform the DCF analysis on non-price regulated proxy group as Mr. D'Ascendis did.

Dr. Carlisle's CAP-M analysis compared the returns of the companies in his water company proxy group to a "risk free rate of return" (projected 30 yr. Treasury bond yield). R. p. 658 (Carlisle Direct, p. 13, ll. 17-23). Dr. Carlisle's CAP-M analysis produced a range of 9.38% to 9.70%, which he averaged for a final CAP-M rate of 9.54%. R. p. 659 (Carlisle Direct, p. 14, ll. 12-13). Dr. Carlisle did not perform the CAP-M analysis on comparable non-price regulated stocks, as Mr. D'Ascendis did.

Dr. Carlisle's CEM analysis, was applied to a group of non-price regulated stocks selected from Value Line with a comparable price volatility factor ("beta" or "ß") to those in his water company proxy group. R. p. 655 (Carlisle Dir. p. 10, ll. 1-6). The CEM analysis produced a "retrospective" return on equity of 9.15%, and a "prospective" ROE of 8.63%. Dr. Carlisle averaged the two to arrive at a CEM ROE of 8.89%. R. p. 656 (Carlisle Dir. p. 11, ll. 3-7).

Finally, Dr. Carlisle averaged his DCF, CEM, and CAP-M rates to arrive at his recommended ROE of 9.08%.

Mr. D'Ascendis and Dr. Carlisle disagreed often. Mr. D'Ascendis argued that Dr. Carlisle should have relied on analysts' estimates of earnings per share rather than historical and projected measures of book value per share, dividends per share, and sales growth to predict growth in earnings per share when performing his DCF analysis. R. p. 438 (D'Ascendis, Rebut. p. 3, l. 15 – p. 7, l. 5). On the other hand, Dr. Carlisle took issue with Mr. D' Ascendis' reliance on analysts' projections of earnings per share ("EPS") as the sole factor in his DCF analysis. R. pp. 666–667 (Carlisle Surr. p. 5, l. 8 – p. 6, l. 12). Dr. Carlisle, instead, also considers dividends per share ("DPS"), book value per share ("BPS"), and revenue or sales. R. pp. 650-651 (Carlisle Dir., pp. 6-7). Mr. D'Ascendis pointed to common market references, such as Yahoo Finance and Bloomberg, which provide earnings per share projections, but not projections of dividends per share, book value per share or sales growth, as evidence the investment community relies on the former but not the latter. R. p. 458, l. 24 – p. 459, l. 13. Had he done so, Mr. D'Ascendis testified, Dr. Carlisle's analysis would have produced a higher ROE. R. p. 442 (D'Ascendis Rebut., p. 7, ll. 1-5). Dr. Carlisle disagreed, citing studies showing that analysts' estimates have been historically overly optimistic, and should not be the sole basis for the DCF analysis. R. pp. 664–666 (Carlisle, Surr. p. 3, l. 6 – p. 5, l. 4).

Mr. D'Ascendis also disagreed with Dr. Carlisle' CAP-M calculations. He argued that Dr. Carlisle used the wrong measures of market return, and that he should have used the arithmetic mean of monthly total return rates instead of a geometric mean (or compound growth rate). Mr. D'Ascendis contends using the arithmetic produces the best insight into future returns. R. pp. 443–445 (D' Ascendis Rebut. pp. 8-10). Dr. Carlisle responded that his market return measure better reflects the variety of companies in the market. Dr. Carlisle also defended his use of the geometric mean arguing that the arithmetic mean ignores the "compounding" effect of investing and can mislead investors by masking over the ups and downs of the market. R. p. 668 (Carlisle Surr. p. 7, l. 5 – p. 10, l. 26).

Mr. D'Ascendis criticized Dr. Carlisle for not performing an ECAP-M analysis, which he testified would have produced an equity cost rate of 10.03%. R. pp. 444–445 (D'Ascendis Rebut. p. 9, l. 8 – p. 10, l. 9). Mr. D'Ascendis also testified that Dr. Carlisle's selection of non-price regulated companies for his CEM analysis failed to reflect the total risk of his water company proxy group. Mr. D'Ascendis performed Dr. Carlisle's DCF and CAP-M analyses using a group that better reflected the risk of the water proxy group and found cost rates of 14.66% and 9.85% respectively. R. p. 448 (D'Ascendis Rebut. p. 13, ll. 14-24). Using the amended proxy group, Dr. Carlisle's range would change to 9.57% (DCF), 10.03% (CAP-M), and 12.26% (CEM) with an average of 10.62%. R. p. 449 (D'Ascendis Rebut. p. 14, ll. 4-10).

The Commission finds Mr. D'Ascendis' arguments persuasive. He provided more indicia of market returns, by using more analytical methods and proxy group calculations. Mr. D'Ascendis' use of analysts' estimates for his DCF analysis is supported by consensus, as is his use of the arithmetic mean. The Commission also finds that Mr. D'Ascendis' non-price regulated proxy group more accurately reflects the total risk faced price regulated utilities and CWS. Furthermore, there is no dispute that CWS is significantly smaller than its proxy group counterparts, and, therefore, it may present a higher risk. . An appropriate ROE for CWS is 10.45% to 10.95%. The Company used an ROE of 10.5% in computing its Application, a return on the low end of Mr. D'Ascendis' range, and the Commission finds that ROE is supported by the evidence.

Table 1 below indicates the capital structure of the Company, the cost of debt, the cost of equity as approved in this Order, and the resulting rate of return on rate base:

Table 1: Summary of Overall Rate of Return

Type of Capital	Ratios	Cost Rate	Weighted Cost Rate
Long-Term Debt	48.11%	6.60%	3.17%
Common Equity	51.89%	10.50%	5.45%
Total	100.00%		8.62%

D. Contested Rate Base Adjustments

The rate base proposed by CWS for combined operations was $54,853,170. App. Ex B., Sch. C. CWS disputed two of ORS's rate base adjustments: Adj. 32(c) in which ORS proposes to disallow $1,081,375 spent in connection with a liner of the equalization basin ("EQ Liner") at the Friarsgate wastewater treatment plant, and Adj. 32(d) in which ORS proposes to disallow $306,552 in engineering costs incurred at the Friarsgate Plant. R. p. 744 (Payne Direct, p. 17).

1. Friarsgate EQ Basin Removal and Site Remediation

The Company proposes to include $1,081,375 for engineering costs and remediation costs associated with the replacement of the Equalization Basin's ("EQ") liner at the Friarsgate WWTF. An EQ Liner is a heavy-mill plastic liner placed in an in-ground basin that holds water. R. p. 478, ll. 20-24. CWS hired an engineering firm, W.K. Dickson, after an upset occurred at its Friarsgate Wastewater Treatment Facility ("Friarsgate Plant"). W.K. Dickson assisted CWS in formulating and presenting a Corrective Action Plan required by a Consent Order with DHEC. R. p. 555, l. 16 – p. 557, l. 1. W.K. Dickson submitted engineering plans on an expedited basis for various changes and improvements made to the plant. R. p. 555, ll. 19-25. DHEC also required CWS to have a professional engineer who was a wastewater expert on site to supervise the plant's operations. R. p. 556, ll. 14-22. W.K Dickson also provided required monthly reports to DHEC. R. p. 556, l. 22 – p. 557, l. 1.

The Company was required by a DHEC Consent Order to: 1) remove the existing liner, 2) complete any environmental mitigation efforts concerning the soils under the existing liner, and 3) replace the EQ Liner. This effort included removing and properly disposing of any affected soils. Once the site was sufficiently mitigated, new soil was brought in, graded, and compacted to prepare the site for the installation of the new liner. Although the EQ plastic liner has yet to be installed, the Company removed the existing

EQ Liner and completed the environmental mitigation required by DHEC before the audit cutoff date of February 12, 2018. CWS acted expeditiously to comply with the DHEC mandate. CWS is not asking to recover the cost of the new liner. R. p. 505, ll. 8-14.

CWS witness Cartin testified that the DHEC Consent Order required CWS to remove the EQ Liner at the Friarsgate Plant, remediate the soil underneath the liner, and replace the liner. R. pp. 318-319 (Cartin Rebut. p. 3, l. 3 – p. 4, l. 2). CWS spent $1,081,375 to remove the EQ Liner and remediate the soil under the liner. Id. The Company had not installed the new liner yet but is in the process of doing so. Id. CWS contends that its compliance with DHEC's Consent Order was required for its continued operations and the public has benefitted from the removal of the old EQ Liner and the soil remediation, and therefore the costs should be included in rate base. Id.

The ORS proposes to disallow these costs because the EQ Liner has not yet been replaced. The ORS reasons that the project included both the engineering and remediation and the replacement of the EQ Liner. ORS's witness, Zachary Payne, testified that, since the new EQ Liner is still under construction, the whole project is not used and useful and should not be included in rate base. R. p. 754 (Payne Surr. p. 4, ll. 7-17).

The Commission finds the measures required by the DHEC Consent Order were in the public interest. Disallowing recovery of remediation costs acts to impair a utility's ability to address environmental concerns and conflicts with the policy of allowing recovery of necessary and prudently incurred costs. These known and measurable expenditures provided prompt regulatory and environmental compliance and immediate environmental and customer benefits. CWS has not requested recovery of the cost of the new EQ Liner, the part of the project that ORS challenges as not used and useful. The Commission finds the $1,081,375 cost of the removal of the existing EQ Liner and environmental remediation served the Company's customers and the public interest, and the Company is entitled to its recovery.

2. Friarsgate Engineering Costs

ORS proposed to disallow $306,552 in engineering costs paid to the W.K. Dickson firm for services at the Friarsgate Plant. R. p. 744 (Payne Direct, p. 17, l. 11 (Adj. 32(d)). CWS contends the costs are recoverable because W.K. Dickson was hired to comply with the terms of the Consent Order with DHEC. R. pp. 319-320 (Cartin Rebut. p. 4, l. 3 – p. 5, l. 4). Mr. Cartin testified that W.K. Dickson was hired to design an O&M Manual and take other measures to ensure compliance at the plant. Id. Mr. Gilroy testified that W.K. Dickson was continuously present at the plant following an upset that occurred in June 2016 whichled to a DHEC enforcement action. R. p. 353 (Gilroy Direct p. 10 ll. 1-7); R. p. 487, l. 12 – p. 488, l. 9. During that period, W.K. Dickson served as the principal point of contact with DHEC personnel and obtained permission for changes and improvements made to the facility. Id.

ORS took the position the W.K. Dickson costs should not be recoverable because they were incurred to comply with DHEC's Consent Order, which was caused by the Company's failure to adequately operate and maintain the Friarsgate Plant. R. p. 683, ll. 5-22. ORS's witness, Mr. Schellinger also testified the invoices for the work lacked sufficient detail to allow it to determine the work performed, and the work was required by Consent Orders which arose from the Company's violation of its NPDES permit. R.

pp.712-715 (Schellinger Surr. p. 5, l. 13 – p. 8, l. 20). If the costs were allowable, Mr. Schellinger testified that they should be booked as operations and maintenance expenses, not capital assets. CWS responded that costs incurred to ensure the Company's compliance with environmental regulations should be recoverable, and that treating them as capital expenditures is consistent with the practice adopted by the Company and the ORS in the settlement of the last rate case. R. pp. 319 - 320 (Cartin Rebut. p. 4, l. 3 – p. 5, l. 4). The Commission finds the engineering fees are recoverable as a capital expense prudently incurred to ensure necessary compliance with environmental regulations.

E. Expenses

CWS contested adjustments proposed by the ORS to the Company's O&M expenses: a reduction of $96,892 in sludge hauling expenses (Adj. 9(d)), and the disallowance of $998,606 in legal expenses incurred during litigation involving the I-20 wastewater treatment plant (Adj. 16).

1. Adjustment for Litigation Expenses

The Company proposes to amortize $998,606 in financial costs and litigation expenses associated with its I-20 sewer system over 66.67 years. R, pp. 316-317 (Cartin Rebut., p. 1, l. 12 – p. 2, l. 18). These costs were primarily incurred with five actions: 1) a lawsuit brought by the Congaree Riverkeeper in the U.S. District Court, 2) a condemnation action brought by the Town of Lexington, 3) a challenge to DHEC's denial of a permit for the I-20 Plant in the Administrative Law Court, 4) the Town of Lexington's challenge of DHEC's order that it interconnect with CWS brought in the Administrative Law Court, and 5) CWS's lawsuit against the EPA in the United States District Court. Schellinger Sur.

p. 3, ll. 1-11. The Company proposed to amortize these costs over 66.7 years, resulting in an expense of $14,979 per year. R. p. 300 (Cartin, Dir., p. 2, ll. 15-18).

ORS argued the legal expenses should not be allowed for two reasons. Mr. Schellinger testified that legal expenses incurred to defend the Congaree Riverkeeper's lawsuit should not be allowed because the District Court had ruled against CWS finding various violations of its NPDES permit and of effluent limitations since 2009. R. p. 692 (Schellinger Surr. p. 3, l. 11 – p. 4, l. 5). Mr. Schellinger viewed the company's lawsuit against the EPA and its litigation in the Administrative Law Court as related to the Riverkeeper proceeding, a position not disputed by CWS. Schellinger asserts that CWS should not be allowed to recover its legal costs because the actions arose from the Company's violations of environmental regulations. Id.

Schellinger testified the legal costs incurred in the condemnation action should not be recovered because CWS may be allowed to recover some costs if it prevailed. R. p. 730 (Schellinger Surr. p. 4, ll. 6-22). Schellinger also posited the actions before the Administrative Law Court could turn on the outcome of the condemnation action. R. p. 731 (Schellinger Surr. p. 5, ll. 1-12). He testified that since the outcome of the condemnation action was unknown and since if successful CWS may recover its litigation costs, the Commission should establish a regulatory asset in which to defer the litigation costs for future rate making treatment.

Mr. Cartin testified that CWS had no choice but to defend the Congaree Riverkeeper's lawsuit, and to prosecute its related actions. R. p. 490, l. 22 – p. 491, l. 7. He pointed out the Congaree Riverkeeper brought his suit to force an interconnection of the I-20 Plant to the Town of Lexington's sewer system, an action CWS was ready to take but the Town of Lexington would not allow. R. p. 489, ll. 8-20. It was not until 2016, after DHEC ordered the Town of Lexington to seek an interconnection with CWS, that Lexington brought its condemnation proceeding. R. p. 567, ll. 1-12. When the condemnation suit was brought, CWS readily allowed the town to take possession of the I-20 system and interconnect the plant, reserving its right to contest Lexington's valuation of the plant. Id.

The Commission finds that regulated utilities, like any business, will experience litigation costs associated with its business operations. CWS acted to limit exposure to liability and benefit the utility and its rate payers. The financial and litigation costs were prudently incurred. Recovery of these costs equates to $14,979 in annual amortization expense. As Mr. Cartin testified, CWS had no alternative but to defend the Congaree Riverkeeper's lawsuit and engage in the related litigation. Therefore, CWS will be allowed to recover $998,606 amortized over 66.7 years, at the rate of $14,979 per year.

2. Sludge Hauling Expenses

CWS incurred $284,233 in sludge hauling expenses at its Friarsgate Plant and at its Watergate wastewater treatment facility ("Watergate Plant") during the test year. R. p. 753 (Payne Surr. p. 3). ORS proposed to remove $96,892 in sludge hauling costs. ORS proposes an adjustment to allow recovery of a three-year average of annual sludge hauling costs at the two facilities.

ORS witness Payne testified that the ORS reviewed the sludge costs in the test year and the costs in the previous two years, concluding that the sludge hauling costs in the test year were atypical. R. pp. 751-752 (Payne Surr. p. 2, l. 19 – p. 3, l. 12). The ORS proposes to average the annual sludge expense for the three years reviewed and proposed an adjustment of $96,892, normalizing this operating expense. Id.

CWS witness Gilroy testified the increase of sludge hauling expense during the test year was caused by additional sludge removal requirements at the Friarsgate WWTF which produces large amounts of sludge that must be disposed of in a timely manner. R. pp. 358-360. The amount of sludge produced depends on many factors within the process of the waste water treatment. Id. The active sludge inventory within the process must be kept at a certain concentration for the biological process to be effective and result in a clear compliant effluent. Id. Excess sludge inventory must be removed frequently to keep sludge from building up to unacceptable levels which could cause problems with effluent quality. Id.

Mr. Gilroy testified that because the Friarsgate WWTF has been on a Consent Order, these sludge inventories are also monitored by DHEC, which recommends that the inventory to be kept at a constant rate. R. p. 365 (Gilroy Rebut. p. 3, ll. 3-12)). Ordinarily, the liquid sludge is poured into filtrate boxes that drain off the water leaving a very dry cake behind, which is then hauled and disposed of at the Northeast Sanitary Landfill. Id. When the sludge production exceeds the capacity of the filtrate boxes, CWS utilizes contractor liquid tanker trucks to haul the sludge to the City of Cayce's disposal site. Id. Disposing of the sludge in the cake form is more cost-effective than hauling truckloads of liquid sludge. Id. Although more expensive, sometimes the filtrate boxes are full, and tankers must be utilized. Id.

The Commission finds that the sludge hauling costs in the test year are recoverable as known and measurable, prudently incurred costs. The ORS does not dispute the sludge costs in the test year. It simply speculates that the costs will not recur in a similar amount. Speculation is not sufficient. Moreover, the testimony indicates that the sludge costs have increased because of the DHEC Consent Order, and were prudently incurred. The Commission denies the ORS adjustment to reduce the sludge hauling expenses.

3. Effects of the Income Tax and Jobs Act

a) Excess Accumulated Deferred Income Taxes

The Company filed its Application before Congress enacted the Tax Cuts and Jobs Act of 2017 ("TCJA"), which took effect on January 1, 2018. P.L. No: 115-97. The TCJA changed the tax laws affecting the Company. Mr. Hunter testified the TCJA reduced the corporate income tax rate from 35% to 21%, causing the Company to reduce its requested revenue requirement by approximately $877,000. R. p. 255, ll. 16-22. This Commission held in Order No. 2018-308 that, beginning January 1, 2018, regulatory accounting treatment is required for all regulated utilities for any impacts of the new law, including current and deferred tax impacts. We also held that the utilities should track and defer the effects resulting from the Tax Act in a regulatory liability account, and further, for water/wastewater utilities with operating revenues that are equal or greater than $250,000, the issue will be addressed at the next rate case or other proceeding. The provisions of Order No. 2018-308 apply to the present case, as well as to other utilities indicated in Order No. 2018-308.

F. Rate Case Expenses

CWS proposed to include rate case expenses incurred in this rate case through the date of the hearing, and ORS agreed to this proposal, subject to its review of the requested additional amount and examination of supporting documentation. R p. 754 (Payne Surreb., p. 4, ll. 5-7). ORS received and reviewed documentation supporting rate case expenses of $88,500 and informed the Commission at the hearing that the ORS agrees with them. After the hearing, CWS presented documentation supporting additional rate case expenses of $64,560. Because the additional rate case expenses are known and measurable, the Commission will allow them to be included in the total rate case expense and amortized over three years. We find the Company is entitled to $153,060 in total rate case expenses, including those expenses submitted to ORS post-hearing. This amount amortized over three years less the Company's per book amount yields a post-hearing adjustment of $21,520.

G. Other Adjustments

The remaining ORS adjustments are accepted by this Commission without discussion. They either were not disputed by the parties or were caused by carrying out the effects of the adjustments adopted above.

H. Deferred Accounts

By Order No. 2015-876 in Docket No. 2015-199-WS, the Commission approved two regulatory deferred accounts authorizing CWS 1) to record and monitor all rate increases from third-party providers for water supply and sewer treatment; and 2) to recover non-revenue water expenses. The Commission authorized CWS to seek recovery of the balance of these deferred accounts, subject to audit by ORS and approval by the Commission in a subsequent rate case. In this Application CWS is seeking recovery of the balance in the regulatory deferral account associated with increases in purchased water from bulk water providers. (Application, para. 17) Mr. Hunter testified that the purchase water deferred account had a balance of $669,808 as of March 8, 2018 and explained CWS sought recovery of this balance in this docket R. p. 278 (Hunter Rebut. p. 3 ll. 7–17). At the hearing, Mr. Payne testified that the ORS had reviewed the supporting documentation of the purchase water deferred account and that the ORS agreed with CWS' request to recover the balance of $669,808. R. p. 752 (Payne Surreb., p. 2, ll.8-18). The Commission finds it reasonable for CWS to recover the purchased water deferred account balance of $669,808.

Because the non-revenue water deferral account has a balance of zero, the ORS recommended this account be closed. R. p. 701 (Schellinger Dir., p. 11, l. 18 – p. 12, l. 8). The Company did not dispute this recommendation. The Commission finds it reasonable that the non-revenue water account be closed.

I. Performance Bond

CWS currently provides the maximum amount required for its performance bond in the amount of $350,000 for water and $350,000 for sewer operations. Using the criteria set forth in S.C. Code Regs. §§ 103-512.3.1 and 103-712.3.1, ORS recommended that CWS be required to continue the current performance bond amounts. R. p. 701 (Schellinger Dir. p. 12, ll. 9-15). CWS agreed to the performance bond amounts. The Commission requires that CWS maintain its performance bond in $350,000 for water and $350,000 for sewer operations.

J. Changes to Rates, Charges and Term of Service

1. Irrigation Only Meters

Mr. Cartin testified that after hearing concerns expressed by customers with irrigation only meters, the Company had determined to eliminate the base facilities charge for irrigation only meters for residential customers who are no longer receiving an economic benefit from having an irrigation meter. The impact on revenues will be $37,946 annually. The Company is not seeking recovery of this lost revenue here. R. p. 320 (Cartin Reb., p. 5, ll. 5-20).

The ORS has no objection to eliminating the base facilities charge on customers with irrigation only meters.

The Commission finds that eliminating the base facilities charge for customers with irrigation only meters is just and reasonable and in the public interest.

2. Backflow Testing.

CWS proposed to change the terms and conditions of its tariff to permit its customers to test their backflow devices every two years. The ORS proposed to limit the testing requirement to every two years for those residential customers with irrigation cross connections. R. pp. 699 - 700 (Schellinger Dir., p. 10, l. 18 – p. 11, l. 6). CWS concurred with the ORS recommendation with the additional provision that if the sewer system utilizes chemical injection, annual testing will be required. R. p. 363 (Gilroy Rebut., p. 1, ll. 1-7).

The Commission finds that permitting CWS' residential irrigation customers to test backflow preventers every two years is reasonable, provided that if the sewer system utilizes chemical injection, annual testing will be required

3. Water Meter Installation Charge

CWS requests authority to increase its Water Meter Installation Charge from$35.00 to $45.00 to more closely reflect the utility's costs. (Application at ¶ 20) The ORS has reviewed the cost justification for this increase and agrees the increase is reasonable. R. p. 699 (Schellinger Dir., p. 10, ll.14 – 17). The $45.00 charge is reasonable and CWS is authorized to increase its Water Meter Installation Charge to $45.00.

4. Limitation of Liability

CWS seeks authority to limit the liability of the Company, its agents and employees for damages arising out of interruption of service or the failure to furnish service, whether caused by acts or omission, to those remedies provided in the Commission's rules and regulations governing water and wastewater utilities. (Application at ¶ 22). Mr. Cartin points out that the Commission has promulgated regulations for quality of service and interruption of service. Limiting customer remedies to those provided in the regulations will eliminate the prospect of unnecessary litigation and result in cost savings which will benefit customers. R. pp. 310-311 (Cartin Dir., p. 12, l. 14 – p. 13 1, l. 2). The ORS does not oppose the Company's proposed changes to tariff language regarding liability for interruption of service. Interruption of service is regulated by the Commission in S.C, Code Ann. Regs. 103-771 and 103-551. R. p. 670 (Schellinger Dir., p. 11, ll. 7–12) The proposed limitation of liability to those protections found in S.C. Code Reg. 103-771 and 103-551 is reasonable and is approved.

K. Authorized Revenues

CWS requested in its Application to increase revenues for combined operations by $4,511,414, comprising a water revenue increase of $2,272,914 and a sewer revenue increase of $2,238,500, based on the rate of return on rate base methodology utilizing an ROE of 10.5% and an historical test year ending August 31, 2017. The revenue and expense adjustments to the requested increase in revenue set out herein at the approved ROE of 10.50% produce additional operating revenue of $2,936,437 consisting of a water revenue increase of $1,286,127 and a sewer revenue increase of $1,650,310.

L. Rate Design

Exhibit "A" to the Application contains the Company's Schedule of Proposed Water Charges. The proposed water rate structure for Territory 1 and Territory 2 will remain the same as approved in Order No. 2015-876. In Territory 1 and Territory 2 there will remain separate charges for Water Supply Customers (where water is supplied by wells owned and operated by CWS) and Water Distribution Customers (where water is purchased from a governmental body or agency or other entity for distribution and resale by CWS). R. p. 264 (Hunter Dir. p. 5, ll. 18–25).

Exhibit "A" to the Application contains the Company's Schedule of Proposed Sewer Charges. Under the existing tariff, the flat rate charge for Sewer Collection & Treatment Only Customers and the flat rate charge for Sewer Collection Only Customers are two different rates. CWS proposes to combine Sewer Collection & Treatment Only

Customers and Sewer Collection Only Customers into one single rate per unit. Separate rates will remain on the tariff for Mobile Homes, and The Village Sewer Collection Customers. R. p. 265 (Hunter Dir., p.6, ll. 16–23).

Rate design is a matter of discretion for the Commission. In establishing rates, it is incumbent upon us to fix rates which "distribute fairly the revenue requirements [of the utility]." See Seabrook Island Property Owners Association v. S.C. Public Service Comm'n, 303 S.C. 493, 499 (1991). Our determination of "fairness" with respect to the distribution of the Company's revenue requirement is subject to the requirement that it be based upon some objective and measurable framework. See Utilities Services of South Carolina, Inc., v. South Carolina Office of Regulatory Staff, 392 S.C. 96, 113-114 (2011).

CWS has combined certain of its sewer rates in this docket moving closer to uniform rates. The water rate design was approved by Order No. 2015-876. No party contests the proposed rate design and it is approved by the Commission.

M. Forty Love Point

The Forty Love Point Homeowners Association intervened questioning sewer service in the neighborhood. Barbara King and Jay Dixon, residents of the Forty Love subdivision, testified that they experienced sewer backups in their homes and chronicled the efforts of CWS to address their concerns. Representatives of CWS and its engineers, DHEC and ORS have met with the witnesses. CWS provides collection only services to Forty Love and Richland County treats the sewage. The witnesses testified that Richland County and CWS should coordinate any remedy for the customer concerns. The witnesses believe their sewer system is outdated and inadequate. The witnesses also contest the proposed rate increase. R. pp. 608–610 (Dixon Dir. p. 1, l. 1 – p. 4, l. 76); R. pp. 603 – 605 (King Dir., p. 1, l. 1 – p. 3, l. 59).

CWS witness Gilroy testified that the Forty Love sewer system is a LETTS design installed by the developer. LETTS systems are modified septic tanks in which solid waste accumulates in a holding tank with the gray water draining to a common sewer main for transport to the Richland County Utilities treatment plant. CWS has been working with the Kings and Dixons to determine why their LETTS tanks fail to drain during prolonged rain events. CWS believes the elevation and distance between their finished basements and the sewer main outside provides for no leeway when the sewer main backs up slightly. CWS has a contractor working to install a pump tank that will both pump their water into the main and provide the separation needed to eliminate backups of their homes. R. pp. 363–364 (Gilroy Rebut., p. 1, l. 8 – p. 2, l. 10).

CWS is also retaining a professional engineering firm to inspect the system and help solve the sewerage backup problems experienced by these customers. While it is working towards a permanent solution, CWS will continue to alleviate the problem by dispatching pump trucks to the neighborhood when heavy rains are anticipated. CWS is also inspecting each LETTS tank and will reseal them as necessary. Reduced water from the tanks should ease the stress placed on thesystem. Id.

CWS will continue to communicate the engineering assessment with the outside contractor with Forty Love. CWS and Forty Love have agreed to report their findings to the Commission and ORS in six months – by September 30, 2018. Id. The Commission finds that the agreement between CWS and Forty Love is reasonable.

CWS and the HOA have agreed to the following plan of action which, at their request, the Commission incorporates in its Order:

> CWS acknowledges that some of its customers in the Forty Love Point neighborhood have experienced problems with sewerage backups. CWS has taken, and will continue to take, measures to address these customers' concerns. CWS and the HOA agree to cooperatively investigate the source and extent of sewerage problems experienced by customers in the Forty Love Point neighborhood and formulate a plan to address them. The company is retaining an engineering firm to perform an assessment of the Forty Love Point system, and CWS will continue to work with DHEC and Richland County to determine whether issues with the latter's system may be affecting Forty Love Point. CWS and the HOA will report their findings to the PSC and the ORS in six months.

N. Dancing Dolphin, LLC

The Commission requested that the ORS investigate the allegations made by CWS' customer the Dancing Dolphin, LLC. The ORS recommends that CWS complete an inflow and infiltration study and a cost benefits analysis for the sewer system serving the properties owned by the Dancing Dolphin. R. pp. 705– 706 (Schellinger Dir., p. 16, l. 20 - -p. 17, l. 3) CWS will conduct an inflow and infiltration study and provide a report to the Commission within one year of the date of the Order. R. pp. 317–318 (Cartin Rebut., p. 2, 19 - p. 3, l. 2). In addition, CWS has credited the Dancing Dolphin, LLC with one month's bill to address the customer's concerns. R. p. 310 (Cartin Dir. p. 12, ll. 12–13). The Commission finds CWS conduct to be prudent and reasonable.

O. Customer Communications

The record reflects that CWS is working to give its customers a better understanding of the pressures and costs of operating its water and sewer systems. The Company has hired a communications coordinator to direct its customer outreach activities. R. pp. 251-253. Since December of 2017, CWS scheduled meetings with its customers in York County on December 4, 2017, and February 27, 2018; Lexington County on December 5, 2017; Anderson County on December 6, 2017; Richland County on February 21, 2018, and Greenville County on March 1, 2018. At those meetings, CWS gave customers the opportunity to meet with its management and field personnel to learn more about its operations and cost of service. R. p. 371 (Gilroy Resp., p.1, ll. 6–16).

This Commission would observe that, in prior years, the Company's customer service was perceived by some as being below standard. However, the Company's testimony in this case shows that it is committed to improvement in a proactive fashion. Relatively few customers appeared to complain about quality of service, as compared to the last several rate cases. We hold that the Company should routinely be responsive on quality of service issues, and that CWS should set the standard for quality and customer service.

However, in order to ensure that the Company is being responsive to quality of service issues, and to its customers, CWS shall prepare a report and submit it to the Commission and to ORS no less than semiannually, and the document should have headings for "Customer Complaint," "Company Response," "Customer Reaction to Company," and explain the Company reaction to Customer Complaints during the period addressed, along with any explanations regarding quality of service. The Company shall also submit a separate report no less than semiannually reporting on all capital improvements made during the period to enhance customer service and to explain the cost of such capital improvements.

III. FINDINGS OF FACT

1) CWS is a water and sewer utility providing water and sewer service in its assigned service area in South Carolina. The Commission is vested with authority to regulate rates of every public utility in this state and to ascertain and fix just and reasonable rates for service. S.C. §58-5-210, et. seq. CWS's operations in South Carolina are subject to the jurisdiction of the Commission.

2) CWS requested in its Application to increase revenues for combined operations by $4,511,414 comprising a water revenue increase of $2,272,914 and a sewer revenue increase of $2,238,500, based on the rate of return on rate base methodology utilizing an ROE of 10.5% and a historical test year ending August 31, 2017.

3) The test year period for this proceeding, selected by the Company, is September 1, 2016 through August 31, 2017.

4) The Commission will use the return on rate base methodology in determining and fixing just and reasonable rates.

5) The return on rate base methodology requires three components: capital structure, cost of debt, and cost of equity (or ROE).

6) CWS's rate base is $55,524,956 after the adjustments adopted by the Commission.

7) The Commission adopts and approves of a capital structure of 48.11% long-term debt and 51.89% equity; a cost of debt rate of 6.60%; and an ROE of 10.50%.

8) The approved capital structure, cost of debt rate, and ROE produce additional operating revenue of $2,936,437 consisting of a water revenue increase of $1,286,127 and a sewer revenue increase of $1,650,310.

9) The approved revenues and expenses establish a fair and reasonable operating margin of 13.23%, and a return on rate base of 8.62%.

10) The schedule of rates and terms and conditions attached to this Order as Exhibit A (Order Exhibit 1) are just and reasonable and designed to achieve the Company's new revenue requirement.

IV. CONCLUSIONS OF LAW

Based upon the discussion, findings of fact and the record of the instant proceeding, the Commission makes these Conclusions of Law:

1) CWS is a public utility as defined in S.C. Code § 58-5-10(3) and is subject to the jurisdiction of this Commission.

2) The appropriate test year on which to set rates for CWS is the twelve-month period beginning September 1, 2016 and ending August 31, 2017.

3) Based on the information provided by the parties, the Commission concludes the rate setting methodology to use as a guide in determining the lawfulness of CWS's proposed rates and for fixing just and reasonable rates is return on rate base.

4) For CWS to have the opportunity to earn the 10.5% ROE, found fair and reasonable herein, CWS must be allowed additional revenues of $2,936,437.

5) The schedule of rates and terms and conditions in the attached Exhibit A are approved for use by CWS and are just and reasonable without undue discrimination and are also designed to meet the revenue requirements of CWS.

6) Pursuant to S.C. Code § 58-5-720 and 10 S.C. Code Regs. §§ 103-512.3 and 103-712.3, CWS will post a performance bond of $350,000 for water and $350,000 for sewer operations.

V. ORDERING PROVISIONS

IT IS THEREFORE ORDERED THAT:

I. The rates, fees, and charges in Order Exhibit 1 are both fair and reasonable and will allow CWS to continue to provide its customers with adequate water and wastewater services.

II. The Company is to provide thirty (30) days' notice of the increase to customers of its water and wastewater services prior to the rates and schedules being put into effect for service rendered. The schedules will be deemed filed with the Commission under S.C. Code § 58-5-240.

III. An ROE of 10.5%, return on rate base of 8.62% and operating margin of 13.23% based on the new rates, fees, and charges, is approved for CWS.

IV. The Company will continue to maintain current performance bonds in the amounts of $350,000 for water operations and $350,000 for wastewater operations pursuant to S.C. Code § 58-5-720.

V. The Company shall provide the written reports on quality of service and capital improvements no less than semiannually as described above.

VI. This Order will remain in full force and effect until further order of the Commission.

BY ORDER OF THE COMMISSION:

Swain E. Whitfield

Swain E. Whitfield. Chairman

ATTEST:

Comer H Randall

Comer H. Randall. Vice Chairman

EXHIBIT A

Tariff

Carolina Water Service, Inc.
Docket No. 2017-292-WS
SCHEDULE OF PROPOSED RATES AND CHARGES

WATER

Service Territory 1

Monthly Charges - Water Supply Customers Only

Where water is supplied by wells owned and operated by the Utility, the following rates apply:

	Current	Proposed
Residential		
Base Facilities Charge per single-family house, condominium, mobile home, or apartment unit	$14.64 per unit	$14.43 per unit
Residential Commodity Charge	$5.69 per 1,000 gal. or 134 cft.	$5.61 per 1,000 gal. or 134 cft.
Commercial		
Base Facilities Charge by meter size		
5/8" meter *	$ 14.64 per unit	$ 14.43 per unit
3/4" meter	$ 14.64 per unit	$ 14.43 per unit
1" meter	$ 38.10 per unit	$ 37.54 per unit
1.5" meter	$ 76.21 per unit	$ 75.10 per unit
2" meter	$ 121.93 per unit	$ 120.15 per unit
3" meter	$ 228.63 per unit	$ 225.29 per unit
4" meter	$ 381.16 per unit	$ 375.59 per unit
8" meter	$1,171.21 per unit	$1,154.08 per unit
Commercial Commodity Charge	$5.69 per 1,000 gal or 134 cft.	$5.61 per 1,000 gal. or 134 cft.

Monthly Charges - Water Distribution Customers Only

Where water is purchased from a governmental body or agency or other entity for distribution and resale by the Utility, the following rates apply:

	Current	Proposed
Residential		
Base Facilities Charge per single-family house, condominium, mobile home, or apartment unit	$14.64 per unit	$14.43 per unit
Residential Commodity Charge	$6.67 per 1,000 gal. or 134 cft.	$7.57 per 1,000 gal. or 134 cft.

Corrected

Carolina Water Service, Inc.
Docket No. 2017-292-WS
SCHEDULE OF PROPOSED RATES AND CHARGES

	Current	Proposed
Commercial		
Base Facilities Charge		
by meter size		
5/8" meter *	$ 14.64 per unit	$ 14.43 per unit
3/4" meter	$ 14.64 per unit	$ 14.43 per unit
1" meter	$ 38.10 per unit	$ 37.54 per unit
1.5" meter	$ 76.21 per unit	$ 75.10 per unit
2" meter	$ 121.93 per unit	$ 120.15 per unit
3" meter	$ 228.63 per unit	$ 225.29 per unit
4" meter	$ 381.16 per unit	$ 375.59 per unit
8" meter	$1,171.21 per unit	$1,154.08 per unit
Commercial Commodity Charge		
	$6.67 per 1,000 gal. or 134 cft.	$7.57 per 1,000 gal. or 134 cft/

***A "Fire Line" customer will be billed a monthly base facilities charge of a 5/8" meter or at the rate of any other meter size used as a detector.**

Corrected

Carolina Water Service, Inc.
Docket No. 2017-292-WS
SCHEDULE OF PROPOSED RATES AND CHARGES

Service Territory 2

Monthly Charges - Water Supply Customers

Where water is supplied by wells owned and operated by the Utility, the following rates apply:

	Current	Proposed
Residential		
Base Facilities Charge per single-family house, condominium, mobile home or apartment unit:	$24.72 per unit	$28.62 per unit
Residential Commodity Charge	$ 8.88 per 1,000 gal. or 134 cft.	$10.28 per 1,000 gal. or 134 cft.
Commercial		
Base Facilities Charge by meter size		
5/8" meter*	$ 24.72 per unit	$ 28.62 per unit
1" meter	$ 68.81 per unit	$ 79.65 per unit
1.5" meter	$ 126.45 per unit	$146.38 per unit
3" meter	$ 431.52 per unit	$499.53 per unit
Commercial Commodity Charge	$ 8.88 per 1,000 gal. or 134 cft.	$10.28 per 1,000 gal. or 134 cft.

Monthly Charges - Water Distribution Customers Only

Where water is purchased from a governmental body or agency or other entity for distribution and resale by the Utility, the following rates apply:

Residential		
Base Facilities Charge per single-family house, condominium, mobile home or apartment unit:	$ 24.72 per unit	$ 28.62 per unit
Residential Commodity Charge	$ 9.41 per 1,000 gal. or 134 cft.	$ 11.86 per 1,000 gal. or 134 cft.
Commercial		
Base Facilities Charge by meter size:		
5/8" meter*	$ 24.72 per unit	$ 28.62 per unit
1" meter	$ 68.81 per unit	$ 79.65 per unit
1.5" meter	$ 126.45 per unit	$146.38 per unit
3" meter	$ 431.52 per unit	$499.53 per unit
Commercial Commodity Charge	$ 9.41 per 1,000 gal.	$ 11.86 per 1,000 gal.

Carolina Water Service, Inc.
Docket No. 2017-292-WS
SCHEDULE OF PROPOSED RATES AND CHARGES

or 134 cft.	or 134 cft.

***A "Fire Line" customer will be billed a monthly base facilities charge of a 5/8" meter or at the rate of any other meter size used as a detector.**

Carolina Water Service, Inc.
Docket No. 2017-292-WS
SCHEDULE OF PROPOSED RATES AND CHARGES

WATER SERVICE
TERMS AND CONDITIONS
AND
NON-RECURRING CHARGES

1. <u>Terms and Conditions</u>

A. Where the Utility is required by regulatory authority with jurisdiction over the Utility to interconnect to the water supply system of a government body or agency or other entity and tap/connection/impact fees are imposed by that entity, such tap/connection/impact fees will also be charged to the Utility's affected customers on a pro rata basis, without markup.

B. Commercial customers are those not included in the residential category abovc and include, but are not limited to, hotels, stores, restaurants, offices, industry, etc.

C. The Utility will, for the convenience of the owner, bill a tenant in a multi-unit building, consisting of four or more residential units (or in such other circumstances as the law may allow from time to time), which is served by a master water meter or a single water connection. However, in such cases all arrearages must be satisfied before service will be provided to a new tenant or before interrupted service will be restored. Failure of an owner to pay for services rendered to a tenant in these circumstances may result in service interruptions.

D. When, because of the method of water line installation utilized by the developer or owner, it is impractical to meter each unit separately, service will be provided through a single meter, and consumption of all units will be averaged; a bill will be calculated based on that average and the result multiplied by the number of units served by a single meter.

E. <u>Billing Cycle</u>
Recurring charges will be billed monthly in arrears. Nonrecurring charges will be billed and collected in advance of service being provided.

F. <u>Extension of Utility Service Lines and Mains</u>
The Utility shall have no obligation at its expense to extend its utility service lines or mains in order to permit any customer to connect to its water system. However, anyone or entity which is willing to pay all costs associated with extending an appropriately sized and constructed main or utility service line from his/her/its premises to any appropriate connection point, and pay the appropriate fees and charges as set forth in this rate schedule, and comply with the guidelines and standards hereof, shall not be denied service unless water supply is unavailable or unless the South Carolina Department of Health and Environmental Control or other government entity has for any reason restricted the Utility from adding additional customers to the serving water system. In no event will the Utility be required to construct additional water supply capacity to serve any customer or entity without an agreement acceptable to the Utility first having been reached for the payment of all costs associated with adding water supply capacity to the affected water system.

Carolina Water Service, Inc.
Docket No. 2017-292-WS
SCHEDULE OF PROPOSED RATES AND CHARGES

G. Cross-Connection Inspection
Any customer installing, permitting to be installed, or maintain any cross connection between the Utilities water system and any other non-public water system, sewer, or a line from any container of liquids or other substances, must install an approved back-flow prevention device in accordance with 24A S.C. Code Ann. Regs. R.61-58.7.F.2, as may be amended for time to time. Such a customer shall have such cross connection inspected by a licensed certified tester and provide to Utility a copy of written inspection report indicating the back-flow device is functioning properly and testing results submitted by the tester in accordance with 24A S.C. Code Ann. Regs. R.61-58.7.F.2, as may be amended from time to time. Said report and results must be provided by the customer to the Utility no later June 30th of each year for required residential and commercial customers, provided that said report and results for residential irrigation customers shall be provided by the customer to the Utility no later than June 30th of every other year (unless the sewer system utilizes chemical injection for which annual testing will be required). Should a customer subject to these requirements fail to timely provide such report and results, Utility may arrange for inspection and testing by a licensed certified tester and add the charges incurred by the Utility in that regard to the customer's next bill. If after inspection and testing by the Utility's certified tester, the back-flow device fails to function properly, the customer will be notified and given a 30 day period in which to have the back-flow device repaired or replaced with a subsequent follow-up inspection by a licensed certified tester indicating the back-flow device is functioning properly. Failure to submit a report indicating the back-flow device is functioning properly will result in discontinuation of water service to said customer until such time as a passing inspection report is received by Utility.

H. A Single Family Equivalent (SFE) shall be determined by using the South Carolina Department of Health and Environmental Control Guidelines for Unit Contributory Loadings for Domestic Wastewater Treatment Facilities -- 6 S.C. Code Ann. Regs. 61-67 Appendix A, as may be amended from time to time. Where applicable, such guidelines shall be used for determination of the appropriate monthly service and tap fee. The Company shall have the right to request and receive water usage records from the water provider to its customers. In addition, the Company shall have the right to conduct an inspection of the customer's premises. If it is determined that actual flows or loadings are greater than the design flows or loadings, then the Company shall recalculate the customer's equivalency rating based on actual flows or loadings and thereafter bill for its services in accordance with such recalculated loadings.

I. The liability of the Company, its agents and employees for damages arising out of interruption of service or the failure to furnish service, whether caused by acts or omission, shall be limited to those remedies provided in the Public Service Commission's rules and regulations governing water utilities.

Carolina Water Service, Inc.
Docket No. 2017-292-WS
SCHEDULE OF PROPOSED RATES AND CHARGES

2. Non-Recurring Charges

A. Water Service Connection (New connections only) - $300 per SFE

B. Plant Impact Fee (New connections only) - $400 per SFE

The Plant Capacity Fee reflects the portion of plant capacity which will be used to provide service to the new customers as authorized by Commission Rule R. 103-702.13. The plant capacity fee represents the Utility's investment previously made (or planned to be made) in constructing water production, treatment and/or distribution facilities that are essential to provide adequate water service to the new customer's property.

C. Water Meter Installation - 5/8 inches x 3/4 inches meter $45.00

All 5/8 inch x 3/4 inch water meters shall meet the Utility's standards and shall be installed by the Utility. A one-time meter fee of $35 shall be due upon installation for those locations where no 5/8 inch x 3/4 inch meter has been provided by a developer to the Utility.

For the installation of all other meters, the customer shall be billed for the Utility's actual cost of installation. All such meters shall meet the Utility's standards and be installed by the Utility unless the Utility directs otherwise.

D. Customer Account Charge – (New customers only) $30.00

A one-time fee to defray the costs of initiating service.

E. Reconnection Charges: In addition to any other charges that may be due, in those cases where a customer's service has been disconnected for any reason as set forth in Commission Rule R.103-732.5, a reconnection fee shall be due in the amount of $40.00 and shall be due prior to the Utility reconnecting service.

F. Tampering Charge: In the event the Utility's equipment, water mains, water lines, meters, curb stops, service lines, valves or other facilities have been damaged or tampered with by a customer, the Utility may charge the customer responsible for the damage the actual cost of repairing the Utility's equipment, not to exceed $250. The tampering charge shall be paid in full prior to the Utility re-establishing service or continuing the provision of service.

Carolina Water Service, Inc.
Docket No. 2017-292-WS
SCHEDULE OF PROPOSED RATES AND CHARGES

SEWER

Service Territory 1 and 2
(Former customers of Carolina Water Service, Inc., Utilities Services of SC, Inc. and United Utility Companies, Inc.)

Former Customers of Carolina Water Service, Inc.

Monthly Charges – Sewer Collection & Treatment Only

Where sewage collection and treatment are provided through facilities owned and operated by the Utility, the following rates apply:

	Current	Proposed
Residential - charge per single-family house, condominium, villa, or apartment unit:	$57.58 per unit	$65.69 per unit
Mobile Homes:	$42.01 per unit	$47.94 per unit
Commercial	$57.58 per SFE*	$65.69 per SFE*

Commercial customers are those not included in the residential category above and include, but are not limited to, hotels, stores, restaurants, offices, industry, etc.

Monthly charge – Sewer Collection Only

When sewage is collected by the Utility and transferred to a government body or agency, or other entity for treatment, the Utility's rates are as follows:

Residential – per single-family house, condominium, or apartment unit	$52.93 per unit	$65.69 per unit
Commercial	$52.93 per SFE*	$65.69 per SFE*
The Village Sewer Collection	$29.95 per SFE*	$34.18 per SFE*

* Single Family Equivalent (SFE) shall be determined by using the South Carolina Department of Health and Environmental Control Guidelines for Unit Contributory Loadings for Domestic Wastewater Treatment Facilities -- 25 S.C. Code Ann. Regs. 61-67 Appendix A, as may be amended from time to time. Where applicable, such guidelines shall be used for determination of the appropriate monthly service and tap fee.

Corrected

SEWER SERVICE

Carolina Water Service, Inc.
Docket No. 2017-292-WS
SCHEDULE OF PROPOSED RATES AND CHARGES

TERMS AND CONDITIONS
AND
NON-RECURRING CHARGES

1. **Terms and Conditions**

A. Where the Utility is required under the terms of a 201/208 Plan, or by other regulatory authority with jurisdiction over the Utility, to interconnect to the sewage treatment system of a government body or agency or other entity and tap/connection/impact fees are imposed by that entity, such tap/connection/impact fees will be charged to the Utility's affected customers on a pro rata basis, without markup.

B. The Utility will, for the convenience of the owner, bill a tenant in a multi-unit building, consisting of four or more residential units (or in such other circumstances as the law may allow from time to time), which is served by a master sewer meter or a single sewer connection. However, in such cases all arrearages must be satisfied before service will be provided to a new tenant or before interrupted service will be restored. Failure of an owner to pay for services rendered to a tenant in these circumstances may result in service interruptions.

C. Billing Cycle
Recurring charges will be billed monthly in arrears. Non-recurring charges will be billed and collected in advance of service being provided.

D. Toxic and Pretreatment Effluent Guidelines
The utility will not accept or treat any substance or material that has been defined by the United States Environmental Protection Agency ("EPA") or the South Carolina Department of Health and Environmental Control ("DHEC") as a toxic pollutant, hazardous waste, or hazardous substance, including pollutants falling within the provisions of 40 CFR 129.4 and 401.15. Additionally, pollutants or pollutant properties subject to 40 CFR 403.5 and 403.6 are to be processed according to pretreatment standards applicable to such pollutants or pollutant properties, and such standards constitute the Utility's minimum pretreatment standards. Any person or entity introducing such prohibited or untreated materials into the Company's sewer system may have service interrupted without notice until such discharges cease, and shall be liable to the Utility for all damages and costs, including reasonable attorney's fees, incurred by the Utility as a result thereof.

E. Extension of Utility Service Lines and Mains
The Utility shall have no obligation at its expense to extend its utility service lines or mains in order to permit any customer to discharge acceptable wastewater into one of its sewer systems. However, anyone or entity which is willing to pay all costs associated with extending an appropriately sized and constructed main or utility service line from his/her/its premises to any appropriate connection point, and pay the appropriate fees and charges as set forth in this rate schedule, and comply with the guidelines and standards hereof, shall not be denied service unless sewer capacity is unavailable or unless the South Carolina Department of Health and Environmental Control or other government entity has for any reason restricted the Utility from adding additional customers to the serving sewer system.

In no event will the Utility be required to construct additional sewer treatment capacity to serve any customer or entity without an agreement acceptable to the Utility first having been reached for the payment of all costs associated with adding wastewater treatment capacity to the affected sewer system.

F. A Single Family Equivalent ("SFE") shall be determined by 6 S.C. Code Ann. Regs. 61-67 Appendix A, as may be amended from time to time. Where applicable, such guidelines shall be used for determination of the appropriate monthly service, plant impact fee and tap fee. The Company shall have the right to request and receive water usage records from the water provider to its customers. In addition, the Company shall have the right to conduct an inspection of the customer's premises. If it is determined that actual flows or loadings are greater than the design flows or loadings, then the Company shall recalculate the customer's equivalency rating based on actual flows or loadings and thereafter bill for its services in accordance with such recalculated loadings.

G. The liability of the Company, its agents and employees for damages arising out of interruption of service or the failure to furnish service, whether caused by acts or omission, shall be limited to those remedies provided in the Public Service Commission's rules and regulations governing wastewater utilities.

2. **Solids Interceptor Tanks**

For all customers receiving sewage collection service through an approved solids interceptor tank, the following additional charges shall apply:

A. Pumping Charge
At such time as the Utility determines through its inspection that excessive solids have accumulated in the interceptor tank, the Utility will arrange for the pumping tank and will include $150.00 as a separate item in the next regular billing to the customer.

B. Pump Repair or Replacement Charge
If a separate pump is required to transport the customer's sewage from solids interceptor tank to the Utility's sewage collection system, the Utility will arrange to have this pump repaired or replaced as required and will include the cost of such repair or replacement as a separate item in the next regular billing to the customer and may be paid for over a one-year period.

C. Visual Inspection Port
In order for a customer who uses a solids interceptor tank to receive sewage service from the Utility or to continue to receive such service, the customer shall install at the customer's expense a visual inspection port which will allow for observation of the contents of the solids interceptor tank and extraction of test samples therefrom. Failure to provide such visual inspection port after timely notice of not less than thirty (30) days shall be just cause for interruption of service until a visual inspection port has been installed.

Carolina Water Service, Inc.
Docket No. 2017-292-WS
SCHEDULE OF PROPOSED RATES AND CHARGES

3. Non-recurring Charges

A. Sewer Service Connection (New connections only) $300 per SFE

B. Plant Capacity Fee (New connections only) $400 per SFE

The Plant Capacity Fee shall be computed by using South Carolina DHEC "Guide Lines for Unit Contributory Loadings to Wastewater Treatment Facilities" (1972) to determine the single family equivalency rating. The plant capacity fee represents the Utility's investment previously made (or planned to be made) in constructing treatment and/or collection system facilities that are essential to provide adequate treatment and disposal of the wastewater generated by the development of the new property.

The nonrecurring charges listed above are minimum charges and apply even if the equivalency rating of non-residential customer is less than one (1). If the equivalency rating of a non-residential customer is greater than one (1), then the proper charge may be obtained by multiplying the equivalency rating by the appropriate fee. These charges apply and are due at the time new service is applied for, or at the time connection to the sewer system is requested.

C. Notification Fee

A fee of $15.00 shall be charged to each customer per notice to whom the Utility mails the notice as required by Commission Rule R. 103-535.1 prior to service being discontinued. This fee assesses a portion of the clerical and mailing costs of such notices to the customers creating the cost.

D. Customer Account Charge - (New customers only)

$30.00

A one-time fee to defray the costs of initiating service. This charge will be waived if the customer is also a water customer.

E. Reconnection Charges: In addition to any other charges that may be due, in those cases where a customer's service has been disconnected for any reason as set forth in Commission Rule R. 103-532.4 a reconnection fee in the amount of $500.00 shall be due at the time the customer reconnects service. Where an elder valve has been previously installed, a reconnection fee of $40.00 shall be charged.

F. Tampering Charge: In the event the Utility's equipment, sewage pipes, meters, curb stops, service lines, elder valves or other facilities have been damaged or tampered with by a customer, the Utility may charge the customer responsible for the damage the actual cost of repairing the Utility's equipment, not to exceed $250. The tampering charge shall be paid in full prior to the Utility re-establishing service or continuing the provision of service.

SOAH DOCKET NO. 473-21-0538
PUC DOCKET NO. 51415

SOUTHWESTERN ELECTRIC POWER COMPANY'S RESPONSE TO CITIES ADVOCATING REASONABLE DEREGULATION'S THIRD SET OF REQUESTS FOR INFORMATION

Question No. CARD 3-22:

With reference to page 29 of Mr. D'Ascendis' testimony, please provide copies of Mr. Engel's published theoretical and empirical research: (1) in which Mr. Engle has developed, proposed, or tested the PRPM model to estimate a company's cost of equity capital; and (2) that relates to the PRPM.

Response No. CARD 3-22:

1. Please see CARD 3-22 attachments A, B, C.
2. For clarification purposes, the Generalized Autoregressive Conditional Heteroskedasticity ("GARCH") model contemplated by Dr. Robert F. Engle is equivalent to the PRPM used by Mr. D'Ascendis in his analysis. Therefore, the articles included in response to part (1), above, would relate to the PRPM, as they are all relative to GARCH.

Sponsored By: Dylan D'Ascendis	Title: Director, ScottMadden, Inc.
Sponsored By: Dylan D'Ascendis	Title: Director, ScottMadden, Inc.

Journal of Economic Perspectives—Volume 15, Number 4—Fall 2001—Pages 157–168

GARCH 101: The Use of ARCH/GARCH Models in Applied Econometrics

Robert Engle

The great workhorse of applied econometrics is the least squares model. This is a natural choice, because applied econometricians are typically called upon to determine how much one variable will change in response to a change in some other variable. Increasingly however, econometricians are being asked to forecast and analyze the size of the errors of the model. In this case, the questions are about volatility, and the standard tools have become the ARCH/GARCH models.

The basic version of the least squares model assumes that the expected value of all error terms, when squared, is the same at any given point. This assumption is called homoskedasticity, and it is this assumption that is the focus of ARCH/GARCH models. Data in which the variances of the error terms are not equal, in which the error terms may reasonably be expected to be larger for some points or ranges of the data than for others, are said to suffer from heteroskedasticity. The standard warning is that in the presence of heteroskedasticity, the regression coefficients for an ordinary least squares regression are still unbiased, but the standard errors and confidence intervals estimated by conventional procedures will be too narrow, giving a false sense of precision. Instead of considering this as a problem to be corrected, ARCH and GARCH models treat heteroskedasticity as a variance to be modeled. As a result, not only are the deficiencies of least squares corrected, but a prediction is computed for the variance of each error term. This prediction turns out often to be of interest, particularly in applications in finance.

The warnings about heteroskedasticity have usually been applied only to cross-section models, not to time series models. For example, if one looked at the

■ *Robert Engle is the Michael Armellino Professor of Finance, Stern School of Business, New York University, New York, New York, and Chancellor's Associates Professor of Economics, University of California at San Diego, La Jolla, California.*

cross-section relationship between income and consumption in household data, one might expect to find that the consumption of low-income households is more closely tied to income than that of high-income households, because the dollars of savings or deficit by poor households are likely to be much smaller in absolute value than high income households. In a cross-section regression of household consumption on income, the error terms seem likely to be systematically larger in absolute value for high-income than for low-income households, and the assumption of homoskedasticity seems implausible. In contrast, if one looked at an aggregate time series consumption function, comparing national income to consumption, it seems more plausible to assume that the variance of the error terms doesn't change much over time.

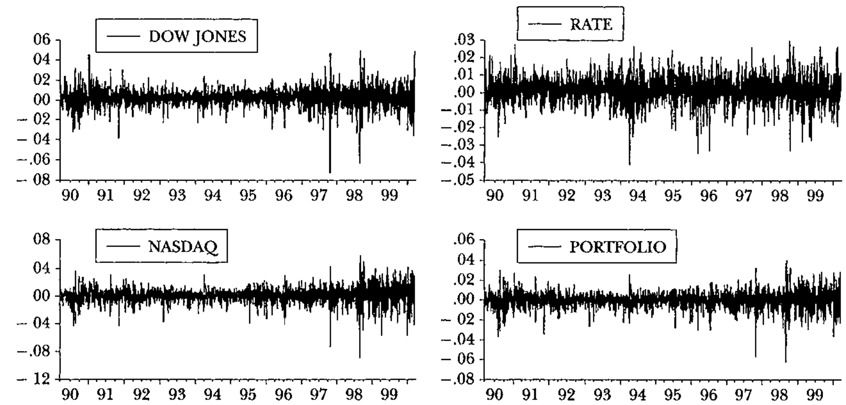
A recent development in estimation of standard errors, known as "robust standard errors," has also reduced the concern over heteroskedasticity. If the sample size is large, then robust standard errors give quite a good estimate of standard errors even with heteroskedasticity. If the sample is small, the need for a heteroskedasticity correction that does not affect the coefficients, and only asymptotically corrects the standard errors, can be debated.

However, sometimes the natural question facing the applied econometrician is the accuracy of the predictions of the model. In this case, the key issue is the variance of the error terms and what makes them large. This question often arises in financial applications where the dependent variable is the return on an asset or portfolio and the variance of the return represents the risk level of those returns. These are time series applications, but it is nonetheless likely that heteroskedasticity is an issue. Even a cursory look at financial data suggests that some time periods are riskier than others; that is, the expected value of the magnitude of error terms at some times is greater than at others. Moreover, these risky times are not scattered randomly across quarterly or annual data. Instead, there is a degree of autocorrelation in the riskiness of financial returns. Financial analysts, looking at plots of daily returns such as in Figure 1, notice that the amplitude of the returns varies over time and describe this as "volatility clustering." The ARCH and GARCH models, which stand for autoregressive conditional heteroskedasticity and *generalized* autoregressive conditional heteroskedasticity, are designed to deal with just this set of issues. They have become widespread tools for dealing with time series heteroskedastic models. The goal of such models is to provide a volatility measure—like a standard deviation—that can be used in financial decisions concerning risk analysis, portfolio selection and derivative pricing.

ARCH/GARCH Models

Because this paper will focus on financial applications, we will use financial notation. Let the dependent variable be labeled r_t, which could be the return on an asset or portfolio. The mean value m and the variance h will be defined relative to a past information set. Then, the return r in the present will be equal to the mean

Figure 1
Nasdaq, Dow Jones and Bond Returns



value of r (that is, the expected value of r based on past information) plus the standard deviation of r (that is, the square root of the variance) times the error term for the present period.

The econometric challenge is to specify how the information is used to forecast the mean and variance of the return, conditional on the past information. While many specifications have been considered for the mean return and have been used in efforts to forecast future returns, virtually no methods were available for the variance before the introduction of ARCH models. The primary descriptive tool was the rolling standard deviation. This is the standard deviation calculated using a fixed number of the most recent observations. For example, this could be calculated every day using the most recent month (22 business days) of data. It is convenient to think of this formulation as the first ARCH model; it assumes that the variance of tomorrow's return is an equally weighted average of the squared residuals from the last 22 days. The assumption of equal weights seems unattractive, as one would think that the more recent events would be more relevant and therefore should have higher weights. Furthermore the assumption of zero weights for observations more than one month old is also unattractive. The ARCH model proposed by Engle (1982) let these weights be parameters to be estimated. Thus, the model allowed the data to determine the best weights to use in forecasting the variance.

A useful generalization of this model is the GARCH parameterization introduced by Bollerslev (1986). This model is also a weighted average of past squared residuals, but it has declining weights that never go completely to zero. It gives parsimonious models that are easy to estimate and, even in its simplest form, has proven surprisingly successful in predicting conditional variances. The most widely used GARCH specification asserts that the best predictor of the variance in the next period is a weighted average of the long-run average variance, the variance predicted for this period, and the new information in this period that is captured by the most recent squared residual. Such an updating rule is a simple description of adaptive or learning behavior and can be thought of as Bayesian updating.

Consider the trader who knows that the long-run average daily standard deviation of the Standard and Poor's 500 is 1 percent, that the forecast he made yesterday was 2 percent and the unexpected return observed today is 3 percent. Obviously, this is a high volatility period, and today is especially volatile, which suggests that the forecast for tomorrow could be even higher. However, the fact that the long-term average is only 1 percent might lead the forecaster to lower the forecast. The best strategy depends upon the dependence between days. If these three numbers are each squared and weighted equally, then the new forecast would be $2.16 = \sqrt{(1 + 4 + 9)/3}$. However, rather than weighting these equally, it is generally found for daily data that weights such as those in the empirical example of (.02, .9, .08) are much more accurate. Hence the forecast is $2.08 = \sqrt{.02*1 + .9*4 + .08*9}$.

To be precise, we can use h_t to define the variance of the residuals of a regression $r_t = m_t + \sqrt{h_t}\varepsilon_t$. In this definition, the variance of ε is one. The GARCH model for variance looks like this:

$$h_{t+1} = \omega + \alpha(r_t - m_t)^2 + \beta h_t = \omega + \alpha h_t \varepsilon_t^2 + \beta h_t.$$

The econometrician must estimate the constants ω, α, β; updating simply requires knowing the previous forecast h and residual. The weights are $(1 - \alpha - \beta, \beta, \alpha)$, and the long-run average variance is $\sqrt{\omega/(1 - \alpha - \beta)}$. It should be noted that this only works if $\alpha + \beta < 1$, and it only really makes sense if the weights are positive, requiring $\alpha > 0$, $\beta > 0$, $\omega > 0$.

The GARCH model that has been described is typically called the GARCH(1,1) model. The (1,1) in parentheses is a standard notation in which the first number refers to how many autoregressive lags, or ARCH terms, appear in the equation, while the second number refers to how many moving average lags are specified, which here is often called the number of GARCH terms. Sometimes models with more than one lag are needed to find good variance forecasts.

Although this model is directly set up to forecast for just one period, it turns out that based on the one-period forecast, a two-period forecast can be made. Ultimately, by repeating this step, long-horizon forecasts can be constructed. For the GARCH(1,1), the two-step forecast is a little closer to the long-run average variance than is the one-step forecast, and, ultimately, the distant-horizon forecast is the same for all time periods as long as $\alpha + \beta < 1$. This is just the unconditional variance. Thus, the GARCH models are mean reverting and conditionally heteroskedastic, but have a constant unconditional variance.

I turn now to the question of how the econometrician can possibly estimate an equation like the GARCH(1,1) when the only variable on which there are data is r_t. The simple answer is to use maximum likelihood by substituting h_t for σ^2 in the normal likelihood and then maximizing with respect to the parameters. An even simpler answer is to use software such as EViews, SAS, GAUSS, TSP, Matlab, RATS and many others where there exist already packaged programs to do this.

But the process is not really mysterious. For any set of parameters ω, α, β and a starting estimate for the variance of the first observation, which is often taken to be the observed variance of the residuals, it is easy to calculate the variance forecast for the second observation. The GARCH updating formula takes the weighted average of the unconditional variance, the squared residual for the first observation and the starting variance and estimates the variance of the second observation. This is input into the forecast of the third variance, and so forth. Eventually, an entire time series of variance forecasts is constructed. Ideally, this series is large when the residuals are large and small when they are small. The likelihood function provides a systematic way to adjust the parameters ω, α, β to give the best fit.

Of course, it is entirely possible that the true variance process is different from the one specified by the econometrician. In order to detect this, a variety of diagnostic tests are available. The simplest is to construct the series of $\{\varepsilon_t\}$, which are supposed to have constant mean and variance if the model is correctly specified. Various tests such as tests for autocorrelation in the squares are able to detect model failures. Often a "Ljung box test" with 15 lagged autocorrelations is used.

A Value-at-Risk Example

Applications of the ARCH/GARCH approach are widespread in situations where the volatility of returns is a central issue. Many banks and other financial institutions use the concept of "value at risk" as a way to measure the risks faced by their portfolios. The 1 percent value at risk is defined as the number of dollars that one can be 99 percent certain exceeds any losses for the next day. Statisticians call this a 1 percent quantile, because 1 percent of the outcomes are worse and 99 percent are better. Let's use the GARCH(1,1) tools to estimate the 1 percent value at risk of a \$1,000,000 portfolio on March 23, 2000. This portfolio consists of 50 percent Nasdaq, 30 percent Dow Jones and 20 percent long bonds. The long bond is a ten-year constant maturity Treasury bond.[1] This date is chosen to be just before the big market slide at the end of March and April. It is a time of high volatility and great anxiety.

First, we construct the hypothetical historical portfolio. (All calculations in this example were done with the EViews software program.) Figure 1 shows the pattern of returns of the Nasdaq, Dow Jones, bonds and the composite portfolio leading up to the terminal date. Each of these series appears to show the signs of ARCH effects in that the amplitude of the returns varies over time. In the case of the equities, it is clear that this has increased substantially in the latter part of the sample period. Visually, Nasdaq is even more extreme. In Table 1, we present some illustrative

[1] The portfolio has constant proportions of wealth in each asset that would entail some rebalancing over time.

Table 1
Portfolio Data

	NASDAQ	*Dow Jones*	*Rate*	*Portfolio*
Mean	0 0009	0.0005	0 0001	0 0007
Std Dev	0.0115	0.0090	0 0073	0.0083
Skewness	−0.5310	−0.3593	−0 2031	−0 4738
Kurtosis	7 4936	8 3288	4.9579	7.0026

Sample: March 23, 1990 to March 23, 2000

statistics for each of these three investments separately and for the portfolio as a whole in the final column. From the daily standard deviation, we see that the Nasdaq is the most volatile and interest rates the least volatile of the assets. The portfolio is less volatile than either of the equity series even though it is 80 percent equity—yet another illustration of the benefits of diversification. All the assets show evidence of fat tails, since the kurtosis exceeds 3, which is the normal value, and evidence of negative skewness, which means that the left tail is particularly extreme.

The portfolio shows substantial evidence of ARCH effects as judged by the autocorrelations of the squared residuals in Table 2. The first order autocorrelation is .210, and they gradually decline to .083 after 15 lags. These autocorrelations are not large, but they are very significant. They are also all positive, which is uncommon in most economic time series and yet is an implication of the GARCH(1,1) model. Standard software allows a test of the hypothesis that there is no autocorrelation (and hence no ARCH). The test p-values shown in the last column are all zero to four places, resoundingly rejecting the "no ARCH" hypothesis.

Then we forecast the standard deviation of the portfolio and its 1 percent quantile. We carry out this calculation over several different time frames: the entire ten years of the sample up to March 23, 2000; the year before March 23, 2000; and from January 1, 2000, to March 23, 2000.

Consider first the quantiles of the historical portfolio at these three different time horizons. To do this calculation, one simply sorts the returns and finds the 1 percent worst case. Over the full ten-year sample, the 1 percent quantile times $1,000,000 produces a value at risk of $22,477. Over the last year, the calculation produces a value at risk of $24,653—somewhat higher, but not enormously so. However, if the 1 percent quantile is calculated based on the data from January 1, 2000, to March 23, 2000, the value at risk is $35,159. Thus, the level of risk apparently has increased dramatically over the last quarter of the sample. Each of these numbers is the appropriate value at risk if the next day is equally likely to be the same as the days in the given sample period. This assumption is more likely to be true for the shorter period than for the long one.

The basic GARCH(1,1) results are given in Table 3. Under this table it lists the dependent variable, PORT, and the sample period, indicates that it took the algorithm 16 iterations to maximize the likelihood function and computed stan-

Table 2
Autocorrelations of Squared Portfolio Returns

	AC	*Q-Stat*	*Prob*
1	0.210	115.07	0.000
2	0.183	202 64	0.000
3	0 116	237.59	0.000
4	0.082	255.13	0 000
5	0.122	294 11	0 000
6	0 163	363.85	0 000
7	0.090	384 95	0 000
8	0.099	410.77	0 000
9	0.081	427.88	0.000
10	0.081	445.03	0.000
11	0 069	457.68	0.000
12	0.080	474 29	0 000
13	0 076	489 42	0 000
14	0 074	503 99	0 000
15	0 083	521.98	0 000

Sample: March 23, 1990 to March 23, 2000.

Table 3
GARCH(1,1)

	Variance Equation			
Variable	*Coef*	*St. Err*	*Z-Stat*	*P-Value*
C	1 40E-06	4.48E-07	3 1210	0.0018
ARCH(1)	0.0772	0.0179	4.3046	0.0000
GARCH(1)	0.9046	0 0196	46 1474	0 0000

Notes: Dependent Variable: PORT.
Sample (adjusted): March 23, 1990 to March 23, 2000.
Convergence achieved after 16 iterations
Bollerslev-Woodridge robust standard errors and covariance

dard errors using the robust method of Bollerslev-Wooldridge. The three coefficients in the variance equation are listed as C, the intercept; ARCH(1), the first lag of the squared return; and GARCH(1), the first lag of the conditional variance. Notice that the coefficients sum up to a number less than one, which is required to have a mean reverting variance process. Since the sum is very close to one, this process only mean reverts slowly. Standard errors, Z-statistics (which are the ratio of coefficients and standard errors) and p-values complete the table.

The standardized residuals are examined for autocorrelation in Table 4. Clearly, the autocorrelation is dramatically reduced from that observed in the portfolio returns themselves. Applying the same test for autocorrelation, we now

Table 4
Autocorrelations of Squared Standardized Residuals

	AC	*Q-Stat*	*Prob*
1	0.005	0.0589	0 808
2	0.039	4 0240	0 134
3	−0.011	4.3367	0 227
4	−0 017	5 0981	0.277
5	0.002	5.1046	0.403
6	0.009	5 3228	0.503
7	−0.015	5.8836	0.553
8	−0.013	6 3272	0.611
9	−0.024	7.8169	0.553
10	−0.006	7 9043	0.638
11	−0.023	9 3163	0.593
12	−0.013	9.7897	0 634
13	−0 003	9 8110	0.709
14	0 009	10.038	0.759
15	−0.012	10.444	0.791

find the p-values are about 0.5 or more, indicating that we can accept the hypothesis of "no residual ARCH."

The forecast standard deviation for the next day is 0.0146, which is almost double the average standard deviation of 0.0083 presented in the last column of Table 1. If the residuals were normally distributed, then this would be multiplied by 2.327, because 1 percent of a normal random variable lies 2.327 standard deviations below the mean. The estimated normal value at risk = $33,977. As it turns out, the standardized residuals, which are the estimated values of $\{\varepsilon_t\}$, are not very close to a normal distribution. They have a 1 percent quantile of 2.844, which reflects the fat tails of the asset price distribution. Based on the actual distribution, the estimated 1 percent value at risk is $39,996. Notice how much this value at risk has risen to reflect the increased risk in 2000.

Finally, the value at risk can be computed based solely on estimation of the quantile of the forecast distribution. This has recently been proposed by Engle and Manganelli (2001), adapting the quantile regression methods of Koenker and Basset (1978) and Koenker and Hallock in this symposium. Application of their method to this data set delivers a value at risk = $38,228.

What actually did happen on March 24, 2000, and subsequently? The portfolio lost more than $1000 on March 24 and more than $3000 on March 27. The biggest hit was $67,000 on April 14. We all know that Nasdaq declined substantially over the next year. The Dow Jones average was much less affected, and bond prices increased as the Federal Reserve lowered interest rates. Figure 2 plots the value at risk estimated each day using this methodology within the sample period and the losses that occurred the next day. There are about 1 percent of times the value at risk is exceeded, as is expected, since this is in-sample. Figure 3 plots the same graph for the next year and a quarter, during

Figure 2
Value at Risk and Portfolio Losses In-Sample

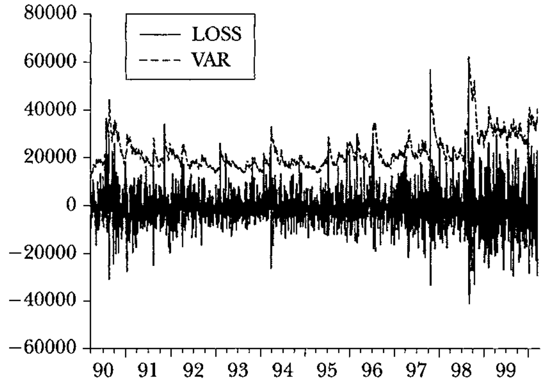
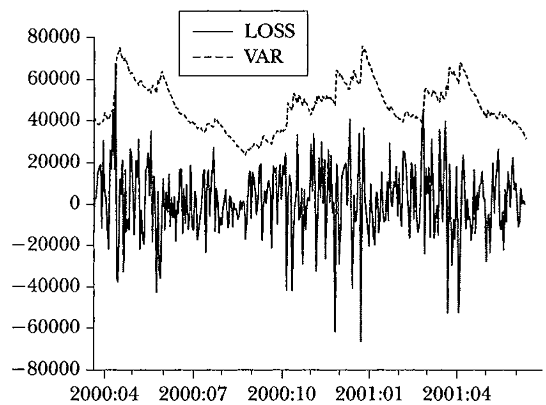


Figure 3
Value at Risk and Portfolio Losses Out of Sample



which the equity market tanks and the bond yields fall. The parameters are not reestimated, but the formula is simply updated each day. The computed value at risk rises substantially from the $40,000 initial figure as the volatility rises in April 2000. Then the losses decline, so that the value at risk is well above the realized losses. Toward the end of the period, the losses approach the value at risk again, but at a lower level. In this year and a quarter, the value at risk is exceeded only once; thus, this is actually a slightly conservative estimate of the risk. It is not easy to determine whether a particular value-at-risk number is correct, although statistical tests can be formulated for this in the same way they are formulated for volatilities. For example, Engle and Manganelli (2001) present a "dynamic quantile test."

Extensions and Modifications of GARCH

The GARCH(1,1) is the simplest and most robust of the family of volatility models. However, the model can be extended and modified in many ways. I will briefly mention three modifications, although the number of volatility models that can be found in the literature is now quite extraordinary.

The GARCH(1,1) model can be generalized to a GARCH(p,q) model—that is, a model with additional lag terms. Such higher-order models are often useful when a long span of data is used, like several decades of daily data or a year of hourly data. With additional lags, such models allow both fast and slow decay of information. A particular specification of the GARCH(2,2) by Engle and Lee (1999), sometimes called the "component model," is a useful starting point to this approach.

ARCH/GARCH models thus far have ignored information on the direction of returns; only the magnitude matters. However, there is very convincing evidence that the direction does affect volatility. Particularly for broad-based equity indices and bond market indices, it appears that market declines forecast higher volatility than comparable market increases do. There is now a variety of asymmetric GARCH models, including the EGARCH model of Nelson (1991), the TARCH model—threshold ARCH—attributed to Rabemananjara and Zakoian (1993) and Glosten, Jaganathan and Runkle (1993), and a collection and comparison by Engle and Ng (1993).

The goal of volatility analysis must ultimately be to explain the causes of volatility. While time series structure is valuable for forecasting, it does not satisfy our need to explain volatility. The estimation strategy introduced for ARCH/GARCH models can be directly applied if there are predetermined or exogenous variables. Thus, we can think of the estimation problem for the variance just as we do for the mean. We can carry out specification searches and hypothesis tests to find the best formulation. Thus far, attempts to find the ultimate cause of volatility are not very satisfactory. Obviously, volatility is a response to news, which must be a surprise. However, the timing of the news may not be a surprise and gives rise to predictable components of volatility, such as economic announcements. It is also possible to see how the amplitude of news events is influenced by other news events. For example, the amplitude of return movements on the United States stock market may respond to the volatility observed earlier in the day in Asian markets as well as to the volatility observed in the United States on the previous day. Engle, Ito and Lin (1990) call these "heat wave" and "meteor shower" effects.

A similar issue arises when examining several assets in the same market. Does the volatility of one influence the volatility of another? In particular, the volatility of an individual stock is clearly influenced by the volatility of the market as a whole. This is a natural implication of the capital asset pricing model. It also appears that there is time variation in idiosyncratic volatility (for example, Engle, Ng and Rothschild, 1992).

This discussion opens the door to multivariate modeling where not only the volatilities but also the correlations are to be investigated. There are now a large number of multivariate ARCH models to choose from. These turn out often to be difficult to estimate and to have large numbers of parameters. Research is continuing to examine new classes of multivariate models that are more convenient for fitting large covariance matrices. This is relevant for systems of equations such as vector autoregressions and for portfolio problems where possibly thousands of assets are to be analyzed.

Conclusion

ARCH and GARCH models have been applied to a wide range of time series analyses, but applications in finance have been particularly successful and have been the focus of this introduction. Financial decisions are generally based upon the tradeoff between risk and return; the econometric analysis of risk is therefore an integral part of asset pricing, portfolio optimization, option pricing and risk management. This paper has presented an example of risk measurement that could be the input to a variety of economic decisions. The analysis of ARCH and GARCH models and their many extensions provides a statistical stage on which many theories of asset pricing and portfolio analysis can be exhibited and tested.

References

Bollerslev, Tim. 1986. "Generalized Autoregressive Conditional Heteroskedasticity." *Journal of Econometrics* April, 31 3, pp 307–27.

Bollerslev, Tim and Jeffrey M. Wooldridge. 1992. "Quasi-Maximum Likelihood Estimation and Inference in Dynamic Models with Time-Varying Covariances." *Econometric Reviews*. 11·2, pp. 143–72.

Engle, Robert F. 1982. "Autoregressive Conditional Heteroskedasticity with Estimates of the Variance of United Kingdom Inflation." *Econometrica*. 50:4, pp. 987–1007.

Engle, Robert and Gary G. J. Lee. 1999 "A Permanent and Transitory Component Model of Stock Return Volatility," in *Cointegration, Causality, and Forecasting: A Festschrift in Honour of Clive W. J. Granger*. Robert F. Engle and Halbert White, eds Oxford: Oxford University Press, pp. 475–97

Engle, Robert F. and Simone Manganelli. 1999. "CAViaR· Conditional Autoregressive Value at Risk by Regression Quantiles." Department of Economics, University of California, San Diego, Working Paper 99–20.

Engle, Robert F. and Simone Manganelli. 2001. "CAViaR: Conditional Autoregressive Value at Risk by Regression Quantiles." Manuscript, University of California, San Diego Revision of NBER Working Paper No. W7341 (1999).

Engle, Robert F. and Joseph Mezrich. 1996. "GARCH for Groups." *RISK*. 9:8, pp 36–40

Engle, Robert F. and Victor Ng. 1993. "Measuring and Testing the Impact of News on

Volatility." *Journal of Finance*. December, 48:5, pp 1749–78.

Engle, Robert, Takatoshi Ito and Wen-Ling Lin. 1990. "Meteor Showers or Heat Waves? Heteroskedastic Intra-Daily Volatility in the Foreign Exchange Market." *Econometrica*. May, 58:3, pp 525–42

Engle, Robert, Victor Ng and M. Rothschild. 1992. "A Multi-Dynamic Factor Model for Stock Returns" *Journal of Econometrics*. April/May, 52: 1–2, pp. 245–66.

Glosten, Lawrence R., Ravi Jagannathan and David E. Runkle. 1993. "On the Relation Between the Expected Value and the Volatility of the Nominal Excess Returns on Stocks." *Journal of Finance* 48:5, pp. 1779–801.

Koenker, Roger and Gilbert Bassett. 1978. "Regression Quantiles." *Econometrica*. January, 46:1, pp. 33–50.

Nelson, Daniel B. 1991. "Conditional Heteroscedasticity in Asset Returns: A New Approach." *Econometrica*. 59:2, pp. 347–70.

Rabemananjara, R. and J. M. Zakoian. 1993 "Threshold Arch Models and Asymmetries in Volatility." *Journal of Applied Econometrics* January/March, 8:1, pp 31–49.

Autoregressive Conditional Heteroscedasticity with Estimates of the Variance of United Kingdom Inflation

Robert F. Engle

Econometrica, Volume 50, Issue 4 (Jul., 1982), 987-1008.

Stable URL:
http //links jstor org/sici?sici=0012-9682%28198207%2950%3A4%3C987%3AACHWEO%3E2.0.CO%3B2-3

Econometrica, Vol 50, No 4 (July, 1982)

AUTOREGRESSIVE CONDITIONAL HETEROSCEDASTICITY WITH ESTIMATES OF THE VARIANCE OF UNITED KINGDOM INFLATION[1]

BY ROBERT F. ENGLE

Traditional econometric models assume a constant one-period forecast variance. To generalize this implausible assumption, a new class of stochastic processes called autoregressive conditional heteroscedastic (ARCH) processes are introduced in this paper These are mean zero, serially uncorrelated processes with nonconstant variances conditional on the past, but constant unconditional variances. For such processes, the recent past gives information about the one-period forecast variance

A regression model is then introduced with disturbances following an ARCH process. Maximum likelihood estimators are described and a simple scoring iteration formulated Ordinary least squares maintains its optimality properties in this set-up, but maximum likelihood is more efficient. The relative efficiency is calculated and can be infinite. To test whether the disturbances follow an ARCH process, the Lagrange multiplier procedure is employed The test is based simply on the autocorrelation of the squared OLS residuals.

This model is used to estimate the means and variances of inflation in the U K The ARCH effect is found to be significant and the estimated variances increase substantially during the chaotic seventies.

1 INTRODUCTION

IF A RANDOM VARIABLE y_t is drawn from the conditional density function $f(y_t | y_{t-1})$, the forecast of today's value based upon the past information, under standard assumptions, is simply $E(y_t | y_{t-1})$, which depends upon the value of the conditioning variable y_{t-1}. The variance of this one-period forecast is given by $V(y_t | y_{t-1})$. Such an expression recognizes that the conditional forecast variance depends upon past information and may therefore be a random variable. For conventional econometric models, however, the conditional variance does not depend upon y_{t-1}. This paper will propose a class of models where the variance does depend upon the past and will argue for their usefulness in economics. Estimation methods, tests for the presence of such models, and an empirical example will be presented.

Consider initially the first-order autoregression

$$y_t = \gamma y_{t-1} + \epsilon_t$$

where ϵ is white noise with $V(\epsilon) = \sigma^2$. The conditional mean of y_t is γy_{t-1} while the unconditional mean is zero. Clearly, the vast improvement in forecasts due to time-series models stems from the use of the conditional mean. The conditional

[1] This paper was written while the author was visiting the London School of Economics He benefited greatly from many stimulating conversations with David Hendry and helpful suggestions by Denis Sargan and Andrew Harvey. Special thanks are due Frank Srba who carried out the computations. Further insightful comments are due to Clive Granger, Tom Rothenberg, Edmond Malinvaud, Jean-Francois Richard, Wayne Fuller, and two anonymous referees. The research was supported by NSF SOC 78-09476 and The International Centre for Economics and Related Disciplines All errors remain the author's responsibility.

variance of y_t is σ^2 while the unconditional variance is $\sigma^2/1-\gamma^2$. For real processes one might expect better forecast intervals if additional information from the past were allowed to affect the forecast variance; a more general class of models seems desirable.

The standard approach of heteroscedasticity is to introduce an exogenous variable x_t which predicts the variance With a known zero mean, the model might be

$$y_t = \epsilon_t x_{t-1}$$

where again $V(\epsilon) = \sigma^2$. The variance of y_t is simply $\sigma^2 x_{t-1}^2$ and, therefore, the forecast interval depends upon the evolution of an exogenous variable. This standard solution to the problem seems unsatisfactory, as it requires a specification of the causes of the changing variance, rather than recognizing that both conditional means and variances may jointly evolve over time Perhaps because of this difficulty, heteroscedasticity corrections are rarely considered in time-series data.

A model which allows the conditional variance to depend on the past realization of the series is the bilinear model described by Granger and Andersen [**13**]. A simple case is

$$y_t = \epsilon_t y_{t-1}.$$

The conditional variance is now $\sigma^2 y_{t-1}^2$. However, the unconditional variance is either zero or infinity, which makes this an unattractive formulation, although slight generalizations avoid this problem.

A preferable model is

$$y_t = \epsilon_t h_t^{1/2},$$

$$h_t = \alpha_0 + \alpha_1 y_{t-1}^2,$$

with $V(\epsilon_t) = 1$. This is an example of what will be called an autoregressive conditional heteroscedasticity (ARCH) model. It is not exactly a bilinear model, but is very close to one. Adding the assumption of normality, it can be more directly expressed in terms of ψ_t, the information set available at time t. Using conditional densities,

$$(1) \qquad y_t \mid \psi_{t-1} \sim N(0, h_t),$$

$$(2) \qquad h_t = \alpha_0 + \alpha_1 y_{t-1}^2$$

The variance function can be expressed more generally as

$$(3) \qquad h_t = h(y_{t-1}, y_{t-2}, \dots, y_{t-p}, \alpha)$$

where p is the order of the ARCH process and α is a vector of unknown parameters.

The ARCH regression model is obtained by assuming that the mean of y_t is given as $x_t\beta$, a linear combination of lagged endogenous and exogenous variables included in the information set ψ_{t-1} with β a vector of unknown parameters. Formally,

$$
\begin{aligned}
& y_t \mid \psi_{t-1} \sim N(x_t\beta, h_t), \\
(4) \qquad & h_t = h(\epsilon_{t-1}, \epsilon_{t-2}, \ldots, \epsilon_{t-p}, \alpha), \\
& \epsilon_t = y_t - x_t\beta.
\end{aligned}
$$

The variance function can be further generalized to include current and lagged x's as these also enter the information set The h function then becomes

$$(5) \qquad h_t = h(\epsilon_{t-1}, \ldots, \epsilon_{t-p}, x_t, x_{t-1}, \ldots, x_{t-p}, \alpha)$$

or simply

$$h_t = h(\psi_{t-1}, \alpha).$$

This generalization will not be treated in this paper, but represents a simple extension of the results. In particular, if the h function factors into

$$h_t = h_\epsilon(\epsilon_{t-1}, \ldots, \epsilon_{t-p}, \alpha) h_x(x_t, \ldots, x_{t-p}),$$

the two types of heteroscedasticity can be dealt with sequentially by first correcting for the x component and then fitting the ARCH model on the transformed data

The ARCH regression model in (4) has a variety of characteristics which make it attractive for econometric applications. Econometric forecasters have found that their ability to predict the future varies from one period to another. McNees [17, p. 52] suggests that, "the inherent uncertainty or randomness associated with different forecast periods seems to vary widely over time." He also documents that, "large and small errors tend to cluster together (in contiguous time periods)." This analysis immediately suggests the usefulness of the ARCH model where the underlying forecast variance may change over time and is predicted by past forecast errors. The results presented by McNees also show some serial correlation during the episodes of large variance.

A second example is found in monetary theory and the theory of finance. By the simplest assumptions, portfolios of financial assets are held as functions of the expected means and variances of the rates of return. Any shifts in asset demand must be associated with changes in expected means and variances of the rates of return If the mean is assumed to follow a standard regression or time-series model, the variance is immediately constrained to be constant over time The use of an exogenous variable to explain changes in variance is usually not appropriate

A third interpretation is that the ARCH regression model is an approximation to a more complex regression which has non-ARCH disturbances. The ARCH specification might then be picking up the effect of variables omitted from the estimated model The existence of an ARCH effect would be interpreted as evidence of misspecification, either by omitted variables or through structural change. If this is the case, ARCH may be a better approximation to reality than making standard assumptions about the disturbances, but trying to find the omitted variable or determine the nature of the structural change would be even better.

Empirical work using time-series data frequently adopts *ad hoc* methods to measure (and allow) shifts in the variance over time. For example, Klein **[15]** obtains estimates of variance by constructing the five-period moving variance about the ten-period moving mean of annual inflation rates Others, such as Khan **[14]**, resort to the notion of "variability" rather than variance, and use the absolute value of the first difference of the inflation rate. Engle **[10]** compares these with the ARCH estimates for U.S. data.

2 THE LIKELIHOOD FUNCTION

Suppose y_t is generated by an ARCH process described in equations (1) and (3) The properties of this process can easily be determined by repeated application of the relation $Ex = E(Ex \mid \psi))$ The mean of y_t is zero and all autocovariances are zero. The unconditional variance is given by $\sigma_t^2 = Ey_t^2 = Eh_t$. For many functions h and values of α, the variance is independent of t. Under such conditions, y_t is covariance stationary; a set of sufficient conditions for this is derived below.

Although the process defined by (1) and (3) has all observations conditionally normally distributed, the vector of y is not jointly normally distributed. The joint density is the product of all the conditional densities and, therefore, the log likelihood is the sum of the conditional normal log likelihoods corresponding to (1) and (3). Let l be the average log likelihood and l_t be the log likelihood of the tth observation and T the sample size. Then

$$
(6)\qquad \begin{aligned} l &= \frac{1}{T}\sum_{t=1}^{T} l_t, \\ l_t &= -\tfrac{1}{2}\log h_t - \tfrac{1}{2} y_t^2 / h_t, \end{aligned}
$$

apart from some constants in the likelihood.

To estimate the unknown parameters α, this likelihood function can be maximized. The first-order conditions are

$$
(7)\qquad \frac{\partial l_t}{\partial \alpha} = \frac{1}{2h_t}\frac{\partial h_t}{\partial \alpha}\left(\frac{y_t^2}{h_t} - 1\right)
$$

and the Hessian is

$$(8)\qquad \frac{\partial^2 l_t}{\partial\alpha\partial\alpha'} = -\frac{1}{2h_t^2}\frac{\partial h_t}{\partial\alpha}\frac{\partial h_t}{\partial\alpha'}\left(\frac{y_t^2}{h_t}\right) + \left[\frac{y_t^2}{h_t} - 1\right]\frac{\partial}{\partial\alpha'}\left[\frac{1}{2h_t}\frac{\partial h_t}{\partial\alpha}\right].$$

The conditional expectation of the second term, given ψ_{t-m-1}, is zero, and of the last factor in the first, is just one. Hence, the information matrix, which is simply the negative expectation of the Hessian averaged over all observations, becomes

$$(9)\qquad \mathcal{I}_{\alpha\alpha} = \sum_t \frac{1}{2T} E\left[\frac{1}{h_t^2}\frac{\partial h_t}{\partial\alpha'}\frac{\partial h_t}{\partial\alpha'}\right]$$

which is consistently estimated by

$$(10)\qquad \hat{\mathcal{I}}_{\alpha\alpha} = \frac{1}{T}\sum_t\left[\frac{1}{2h_t^2}\frac{\partial h_t}{\partial\alpha}\frac{\partial h_t}{\partial\alpha'}\right].$$

If the h function is pth order linear (in the squares), so that it can be written as

$$(11)\qquad h_t = \alpha_0 + \alpha_1 y_{t-1}^2 + \cdots + \alpha_p y_{t-p}^2,$$

then the information matrix and gradient have a particularly simple form. Let $z_t = (1, y_{t-1}^2, \quad, y_{t-p}^2)$ and $\alpha' = (\alpha_0, \alpha_1, \cdot \quad \cdot, \alpha_p)$ so that (11) can be rewritten as

$$(12)\qquad h_t = z_t\alpha.$$

The gradient then becomes simply

$$(13)\qquad \frac{\partial l}{\partial\alpha} = \frac{1}{2h_t} z_t\left(\frac{y_t^2}{h_t} - 1\right)$$

and the estimate of the information matrix

$$(14)\qquad \hat{\mathcal{I}}_{\alpha\alpha} = \frac{1}{2T}\sum_t (z_t' z_t / h_t^2).$$

3 DISTRIBUTION OF THE FIRST-ORDER LINEAR ARCH PROCESS

The simplest and often very useful ARCH model is the first-order linear model given by (1) and (2). A large observation for y will lead to a large variance for the next period's distribution, but the memory is confined to one period. If $\alpha_1 = 0$, of course y will be Gaussian white noise and if it is a positive number, successive observations will be dependent through higher-order moments As shown below, if α_1 is too large, the variance of the process will be infinite.

To determine the conditions for the process to be stationary and to find the marginal distribution of the y's, a recursive argument is required. The odd